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TELECOM 87 – A REPORT

Switch mode power supply
Wide band aerial booster & splitter
The rise & rise of the micro
Portrait of Sir Clive Sinclair

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STRATEGIC ELECTRONICS INITIATIVE (SEI) – THE PAPER WAR

The Department of Electronics has recently brought out two discussion papers devoted to the national policy on electronics and excerpts from the papers appear elsewhere in this issue.

The proposals are high sounding, often abstract. On occasions, it states the obvious but there are some valid observations which need to be taken seriously. The proposals have already received some flak and they are dubbed "Old wine in new bottle".

We cannot be expected to adopt the proposals wholesale. As has been hinted, the papers are meant for public discussion. Hopefully, such discussion will bring out a national consensus, and prune the paper into a workable scheme.

The basic question whether liberalised policy helps in the growth of the industry crops up again. The most widely held and perhaps, a valid view, has been that the growth of India's electronics industry during the last few years is mainly due to the liberal import policies. Yet, the growth has not kept pace with the targets. The new proposals seem to imply invisible bureaucratic controls and here begins the controversy.

A welcome suggestion has been the criterion for foreign collaboration. The gross exports do not reflect the reality. The net foreign exchange earned is, indeed, the real indicator of the export capability of a unit.

Inter-ministerial wrangles proved to be the bane of our policies and they have often resulted in wasteful and avoidable foreign exchange outlay, not to speak of the damage done to indigenous technology development. For mending fences, the bureaucrats need no policy paper and they have to simply realise their collective responsibility.

The discussion papers rightly point out many of the ills afflicting the electronics scene in the country and they have not been diagnosed for the first time. Solutions to these ailments are to be found. That remains to be done by all those concerned with electronics.

Front cover

A computer controlled test system from SIRA measures the optical transfer function and the modulation transfer function of lens systems to give an indication of the quality and the ability to resolve fine details in the image with adequate contrast.

Photograph CROWN *COPYRIGHT RESERVED*

Ites Jubilee

The Indian Technical Education Society, an autonomous body, with over 300 affiliated technical institutes, celebrated its silver jubilee, towards the close of 1987. Apart from conducting examinations in various trades, for which about 10,000 students appear every year, the ITES has set up the Institute of Technicians for aspiring and trained technicians.

Delivering the key note address at a function to mark the silver jubilee, the chairman of Electronics Commission, Mr P.S. Deodhar, pointed out that largely technical institutes lacked in adequate staff which resulted in their poor management. Students in private institutes needed better technical education, he added. Referring to the speech of Mr S.Y. Sule, president, ITES, Mr Deodhar offered to supply kits to the ITES. So far about 350,000 kits have been sold to 100 small scale industries. The department of electronics has decided to begin new courses on manufacturing engineering, mechanical manufacturing process and circuits and designs on chips, according to Mr Deodhar.

Dr P.K. Patwardhan of Bhabha Atomic Research Centre, called for ruralisation of technical education and stressed the need for more privatisation of institutes, resulting in less dependence on the government. More polytechnics and engineering colleges without proper equipment and infrastructure cannot deliver the goods as IITs and engineering colleges produced only trainable boys but not trained ones. Practical training in the industry and in the field filled this gap.

The ITES, by its reputed and professional contributions, turned out as a strong technical Alma Mater, according to Mrs Chitnis, vice-president of ITES, with its office at 173, Vidyanagari Marg, Kalina, Bombay-400 098.

Meltron in Brief

Maharashtra Electronics Corporation Ltd. recorded a turn over of Rs. 17.70 crores in 1986-87, its ninth year of operation. During the year, the first EPABX system based on the C-DOT technology rolled out of the Meltron's ultramodern telematics division at Aurangabad. An outdoor broadcasting van was developed indigenously at the company's audiovisual division at Bombay for the All-India Radio. The company's communication factory at Nagpur supplied to AIR a studio transmitter link.

Meltron's audiovisual division will shortly introduce multi voice logging recorders for use in the defence services and professional mixing consoles and audio racks for studio applications. The radio communication factory at Nagpur proposes to add synthesised portable transreceivers and rugged versions of its existing products for the army and paramilitary forces. The new factory at Aurangabad will take up the production of pulse code modulation equipment and rural automatic exchanges based on indigenous C-DOT technology.

WISITEX 88

The fifth World Instrumentation Symposium and Industrial Electronics Exhibition (WISITEX) will be held from February 4 to 10,1988 in Bombay. The symposium will cover industrial process automation and safety instrumentation, laboratory automation and quality control, medical and bio-technology, new trends in communcication and informatics, advanced manufacturing technologies, advances in materials technology, digital control for power plants and high temperature superconductors and their industrial applications. Buyer-seller meets and release of an electronics and instrumentation directory are the additional features of WISITEX 88.

BEL TRANSMITTER

The end of 1987 saw the beginning of a new era for the Bharat Electronics Ltd. which handed over its first 50 kilowatt short wave transmitter to the government of India. Simultaneously, BEL effected the formal delivery of a one kilowatt medium wave transmitter.

BEL has to deliver 20 SW transmitters of 50 KW range to the AIR. These transmitters are being manufactured under an agreement with Brown Boveri of Switzerland. An automatic turning system in the transmitter enables it to be tuned within three minutes to any frequency in the short wave band.

The one kilowatt medium wave transmitter, is a fully solid state equipment developed as a successor to earlier designs which used valves. BEL has an order for nine of these transmitters.

Derailing Computers

The computerisation plan of the Indian Railways is facing rough weather as the planning commission has suggested drastic pruning of the proposed outlay of Rs.1200 crores. the commission had set up an expert panel to examine the technology upgradation of the railways.

The commission has opined that the project should be taken up in phases with the computerisation of dense areas like workshop, maintenance of the wagon fleet and the railway depots. The expert panel has suggested that railway network computerisation of such an ambitious scale has not been attempted anywhere in the world. In Britain and Canada, location of the wagon fleet was vital since the wagons in these countries are owned by several private parties. In India the entire fleet is owned by the railways.

The panel has asked the basic question if such a computerisation would justify the high costs and whether the railways would be able to find the huge resources, totally estimated at Rs.2200 crores for the project. Selective computerisation of operation intensive areas has been recommended as a solution.

Domestic Snags

The Centre for Development of Telematics, C-DOT, which won acclaim by developing an indigenous electronic exchange in a record time at a given cost, seem to be facing some teething troubles in commercial production. The 512-line exchange was scheduled to be ready by early 1988 but problems relating to the development of necessary software have come in the way. It took giant companies with massive R & D infrastructure nearly a decade to develop the software for digital electronic exchange.

C-DOT is currently testing its 512-line exchange at Delhi Cantonment. Though the calls are going through, some parameters are yet to be fulfilled.

As an exception, the department of telecommunications is believed to have allowed the C-DOT to hook its system to the existing regular telephone network so that the on line problems of the new exchange can be quickly identified. The department always allowed only proved and tested systems to be hooked to its network.

Meanwhile, C-DOT has sought an additional outlay of Rs.52 crores to meet the cost overruns of its 512-line project and to undertake futuristic research in the area of Integrated Services Digital Network. The Planning Commission has approved Rs.18 crores against this request.

The department of electronics and department of telecommunication are supporting their venture, C-DOT, despite the delay in commissioning the projects as the main objective here is indigenisation. The electronic switching system-II depends on the success of the expanded 512-line project. But, the government would wait till the indigenous technology is perfected rather than buying it from abroad.

C-DOT's entry into ISDN, however, is viewed with scepticism by the Planning Commission. Before entering this high technology area, C-DOT would do well to master its 512-line max project, it is felt. But the DOT feels the time is ripe for venturing into ISDN.

Reports indicate that C-DOT is going ahead with its work on the one-lakh line project of ESS-II at ITI Bangalore, by choosing about 140 vendors from all over the country. An estimated 12 million pieces of metal film resistors and 80,000 units of wire wound resistors would be required for the project for which about 40 vendors have been identified. Similarly, vendors have been chosen for the supply of 52.47 lakh ceramic capacitors, 4.06 lakh electrolytic capacitors, 48,000 polysterene capacitors and some tantalum capacitors. Similar transistors, diodes, semiconductor devices, hybrid micro circuits, transformers and IC sockets would be produced.

Strategy And Initiative

A new electronic policy has been proposed by the department of electronics in two discussion papers entitled "Strategic Initiatives for electronics" and "New initiative for R & D in electronics".

The papers puts forth nine objectives for developing indigenous electronics in the country with self reliance as the thrust area in all sectors & the objectives are:

To improve efficiency of agricultural, industrial and commercial infrastructure by ensuring efficient, low cost and high availability voice and data communication; penetrating into remote locations of the country.

To ensure rapid dissemination of productive and educational information in the country through creation of efficient radio, TV and video network;

To harness electronics technology as a tool to bridge the gap between rural and urban India, by emphasising rural development and nation-building activities.

To enable the rural poor to be information rich and to speedily educate country's illiterate and semi literate population through audiovisual media, enabling them to be more productive;

To maximise export growth that will more than balance the foreign exchange outflow needed for essential imports, by creating profitable opportunities to the manufacturers of export and by helping them to be on an equal footing with their world wide competitors.

To strengthen country's defence through strategic development of our own warfare and relevant implements;

To tone up intelligence network and security systems through better hardware maintenance.

To make India a well recognised and sought after source of selected electronic merchandise and services, by capitalising on our strengths such as in computer software, ferrites, labour intensive equipment and components; and to achieve better planning, measurement and mid-course correction through quicker data acquisition, processing and wider access.

Quoting the seventh plan document, the paper estimates the gross output in electronics by 2000 A.D. to be Rs.50,000 crores from the present level of Rs.3,850 crores. The output target for 1989-90 is Rs.10,800 crores.

The procedure for processing industry will be streamlined to the effect that the application processing time will be reduced to 22 weeks from the present 72 weeks, the paper says.

Delicensing will be extended to all sectors of electronics industry which are based on indigenous technology. Delicensing will also be extended to all projects where the design infrastructure capability exists within the country.

Systems in engineering houses and independent commercial R & D houses will be registered as DOE units and will be treated on a par with manufacturers and actual users.

Wherever import of technology is involved, care will be taken to ensure that foreign collaborators do not benefit at the cost of the country. The government will indicate a few norms such as minimum plant capacity and maximum price for plant and fee for technology. The need to import technology is often out of compulsion due to the inability or lack of planning by various user agencies. This will be avoided by appropriate coordination with the user agencies.

Decentralisation of electronics industry approval process by transferring small scale industry approvals to state directorate of industries will enable state level implementation of small projects, according to the paper.

All industries, irrespective of their size, will be asked to submit data about their production and imports to a national data base. No governmental assistance will be available unless all required data in standardised format is submitted along with any application for government assistance.

Thrust will be applied to increase per capita availability of telephone in rural areas.

To encourage production based on indigenous knowhow, special incentives have been proposed. They are:

Reduced duty on capital goods, raw material and components for production based on indigenous R & D; extra excise duty on products made from SKD and CKD kits; total delicensing for indigenous knowhow-based entrepreneurs, with no capacity restriction; those who failed to fulfil the promised indigenisation to be denied further foreign collaboration; expenditure on R & D with the qualification and experience of personnel to be a criterion for deciding indigenisation; imported test equipment, strictly for in house R & D of Indian companies, will be duty free.

On foreign collaborations, the policy paper says that emphasis should be on net foreign exchange earned rather than on the gross value of the export.

Commending the virtue of rationalisation of fiscal policies, the paper says that the long-term import duty structure for materials, components and finished equipment will be further streamlined.

The usual criticism that poor economy of scale of production hindered the electronics industry in India can no longer be true since there is no limit to capacity and foreign collaboration proposals have been approved in large number. However, the home market is not growing and products designed in India and based on Indian components are fewer.

To help expand the market for components, the suggested policy options are: Promoting products which are designed in India; allowing realistic duty drawback and cash assistance to ensure that the cost of materials, machinery and power accessible to the Indian exporters is the same as incurred by his foreign counterparts by refunding all such extra costs; and giving diriect export aid like that of Electronic Sales Support Organisation programme which includes comprehensive assistance from warehousing to office facilities.

If necessary, an Electronics components

development fund may be set up to finance the component industry.

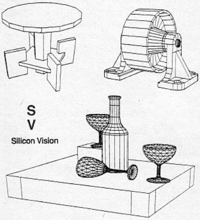
All basic materials needed by the electronics component industry like copper, aluminium, gold-nickel alloys, plastics and adhesives are very expensive in India compared to the world market prices. it is proposed to give a capital base to such industries in public sector as an outright grant and then asking them to compete with imported prices without further assistance. Or else, such basic materials may be made available at concessional duty to the component industry through agencies like ET & T.

The lead paper has called for the formation of a holding company under DOE for the strategically critical areas of electronics where private investment is not forthcoming. The holding company will have the task of investing in major projects such as selected semiconductors and high technology professional equipment.

A centre for excellence in advanced maintainance techniques and maintainability research for computers, communications and control systems will be set up by the DOE. This centre will give technical and managerial guidance in establishing national resource centres for maintenance in different states.

Real-time solids modeller

The *Real-time Solids Modeller* from Silicon Vision provides a sophisticated design tool for creating 3-D solid or wireframe objects of any complexity.



Unlike other packages, this system can perform full colour hidden-surface removal for any solid object at high speed. Colour hard copy of the designs can then be produced on a range of popular pen plotters or printers for professional results. Further information from **Silicon Vision Ltd • 47 Dudley Gardens • HARROW HA2 0DQ • Telephone 01-422 2274.**

CMOS version of 80186

Intel has recently introduced a CHMOS* version of its 80186, a highly integrated microprocessor for embedded control applications in industrial automation, communications, and office automation. It is type-coded 80C186 and is currently available for 12.5 MHz operation; a 16 MHz version will become available shortly.

The 80C186 in compatible mode is pin-for-pin compatible with HMOS* 80186 systems, but it has been enhanced to support Intel's next-generation numerics co-processors.

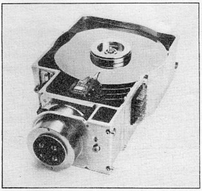
It is claimed that, under normal operating conditions, the 80C186 needs only 20% of the power the HMOS 80186 requires.

*CHMOS and HMOS are patented processes of Intel Corp.

World's fastest 8-inch Winchester disc drive

A new family of 8-inch Winchester disc drives that combine the world's fastest seek performance with a very high level of reliability has been announced by Vermont Research.

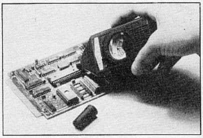
The first product in the new Ascutney family, the model 7030, is a 600 Mbyte unit with extremely fast seek times: a mere 22 ms for full stroke seek, which is nearly 40% faster than most 8-inch disc drives. A rigorous testing programme has established a predicted MTBF of over 30,000 hours.



Full details from **Vermont Research Ltd • Cleeve Road • LEATHERHEAD KT22 7NB • Telephone (0372) 376221.**

Thermoprobe replaces voltmeter

A new, low-cost electronic test instrument called *Thermoprobe* quickly identifies dead active components on PCBs without direct contact.



The solid-state device consists of a thermistor probe connected to a modified wheatstone bridge circuit. It is designed to measure minute temperature changes of 0.02 °C. Since defunct resistors, transformers, diodes, or ICs, do not emit heat they can be quickly identified on the unit's built-in S-meter as the probe is moved in close proximity to them.

Its small size makes the *Thermoprobe* particularly useful in field service applications for computers, electronic instrumentation, video, and hi-fi equipment. It operates from a 9-volt battery.

The *Thermoprobe* is available at $21.95 from **Metrifast • 51 South Denton Avenue • New Hyde Park • New York 11040 • USA.**

Revolutionary electron beam tester

An innovative new system for testing VLSI chips has been introduced by Schlumberger Technologies Automatic Test Equipment. Combining scanning electron microscope (SEM) technology with CAD/CAE tools within a familiar workstation environment, the company's Integrated Diagnostic System (IDS) 5000 Workstation brings unprecedented efficiency and accuracy to the field of VLSI diagnosis and characterization, yet remains easy for engineers to use. The system was launched at the recent *Productronica* trade fair in Munich.

Full details from **Schlumberger Technologies, Automatic Test Equipment • Ferndown Industrial Estate • WIMBORNE BH21 7PP • Telephone (0202) 893535.**

Indian Maritime Communication

India will shortly join the select band of nations in providing a coastal earth station link to the Inmarsat space segment, enabling direct maritime communications between ships and shore based installations.

The Videsh Sanchar Nigam Ltd., a government of India undertaking, will set up the CES at a cost of Rs.16 crores at Arvi near Pune in Maharashtra by mid-1989.

The International Maritime Satellite Organisation (INMARSAT) is an inter-governmental, international body comprising 53 members. India is one of its founder members. Set up in 1979, Inmarsat provides reliable commercial communication links like telephone, telex, data transmission and so on via satellite to all the ships and off-shore users.

In the Inmarsat systems, the INMARSAT organisation provides the satellites or space segment. Presently, nine satellitess have been leased, three each in Indian Ocean, the Pacific and the Atlantic Ocean regions, from the International Satellite Organisation (Intelsat satellitee), the European Space Agency (Marecs satelliotes) and Comsat Organisation of USA (Marisat satellites).

A satellite relays signals received from a ship to distant shore station and from distant shore station to ships. Ship-satellite-ship links use L brand (1.5 GHz/ 1.6GHz) frequencies while shore-satellite-shore links use C band (6 GHz/ 4GHz) frequecies. A ship desirous of having Inmarsat facilities should be equipped with a ship terminal called ship earth station (SES) and it is the responsibility of the ship owner to have one such approved terminal fitted on board.

The present standard A, SES terminal costs US $ 25,000. Inmarsat will soon introduce very cheap and simple ship terminals called standard C terminals. These terminals will cost $ 5,000 each.

The Inmarsat system was put into operation on February 1, 1982 with about six CESs, serving 1000 SESs. By 1987, it grew to serve 6200 ship terminals, including 40 belonging to the Indian maritime fleet, through 20 coastal earth stations. In the Indian Ocean region. Seven CESs operating at present are Yamaguchi (Japan), Eik (Norway), Odessa (USSR), Thermopylae (Greece), Nakhoda (USSR), Jeddah (Saudi Arabia) and Psary (Poland).

Inmarsat is now poised to serve flying aircraft as well as land mobile services like trucks and railways. It has plans to provide communication links to flying aeroplanes to carry air traffic control signals, traffic data and speech signals. Inmarsat is procuring new satellites of high capacity to meet the growing demands for ship services and to meet the new air and land services. The second generation satellites to be procured by mid-1988 will have 125 channels for telephone as against the 40 in the existing satellites.

The Indian earth station at Arvi will serve both standard A and standard C ship terminals and flying aircrafts in future. It may be possible to ring up a person flying on board an aircraft from home or office. Operation of this station will result in savings in foreign exchange which is now being spent by the Indian ships for routing their calls through a foreign earth station. Indian ships will spend much less amount in Indian currency by using the Arvi station. Also, the competitive tariff will attract more foreign ships to use our station.

The Arvi station will be linked to the national and international gateway exchanges at Bombay. In addition to conventional telephone, telex and slow speed data services, the station will provide instant communication to Rescue and Coordination Centres from a ship in distress. The station will handle SOS messages from Emergency Position Indicating Radio Beacon system. EPIRBs, being developed by Inmarsat, will get detached from a ship in disaster, float in water surface and contact with water will activate the beacons to transmit signals. The Arvi station will pick these signals and pass on to the rescue centres on a priority basis.

Telecom Commission

The government of India is considering a proposal to set up a "Telecom Commission" on the lines of the Atomic Energy Commission. The commission is expected to oversee telecom operations, evolve policies, formulate the guidelines and determine frequencies of various channels. The day to day operations and implementation of projects will be given to state level telecom bodies.

The idea of Telecom Commission is said to have emanated from Mr Sam Pitroda technology adviser to the Prime Minister and the founder of C-DOT.

With the formation of Telecom Commission, department of telecommunication may be wound up. The department has been functioning both as a policy making body and implementing agency.

Dot Lab

The Department of Telecommunication will set up a Laboratory for research in optic fibre technology at an estimated cost of Rs. 2 crores. The proposed laboratory will have links with the International Telecommunication Union, based in Sweden.

Link With Vienna

A scientist at Bhabha Atomic Research Centre, Bombay, can now directly get information from the International atomic Energy Agency, Vienna, through computer terminals.

The Vienna database is now accessible through International Subscriber Dialling. As an experiment, BARC's computer division connected a computer terminal through a modem to a telephone line with ISD facility. BARC library and information services division formulated a search query in the format that is acceptable to the package that retrieved information from the database.

Command can be given to get the retrieved information file printed at Vienna and the output can be obtained through mail. The retrieved items, either in toto, or any selected portion such as title or author or abstract, can be read by giving appropriate commands. The file containing the retrieved items can also be seen in part based on stipulated conditions. Since data transmission is at the rate of 300 bauds, browsing retrieved items is likely to take a good deal time and consequently it will cost a lot of money.

SWITCH MODE POWER SUPPLY

Following the general introductions into the operation and application of switch mode power supplies in reference [1] and [2], this article discusses a practical design of a versatile, compact and highly efficient SMPSU rated at 2.5 A.

The circuit described here is based around the integrated switch mode power supply controller Type L4960 from SGS. Briefly recapitulating the general introduction in reference [2], this IC has the following features:

- Input voltage range: 9—50 VDC
- Output voltage adjustable between 5 and 40 V.
- Maximum output current: 2.5 A.
- Maximum output power: 100 W.
- Built-in soft start circuitry.
- Stability of internal reference: ±4%.
- Requires very few external components.
- Duty factor: 0—1.
- High efficiency: η up to 90%.
- Built-in thermal overload protection.
- Built-in current limiter for short-circuit protection.

The pinning of the 3 regulators in SGS's L496X series of switch mode regulators is shown in Fig. 1. The Type L4964 is housed in a special 15-pin enclosure, and can supply up to 4 A. The Type L4962 is the least powerful version (1.5 A), housed in a 16-pin DIL package.
The internal organization of the Type L4960 has been discussed with reference to Fig. 1 in [2]. The operation of the on-chip soft start circuitry, and the current limiter, is illustrated by the waveform diagrams in Fig. 2a and 2b, respectively. The thermal shutdown circuit in the L4960 is activated when the chip junction temperature exceeds 150 °C.
For the sake of safety, the proposed SMPSU is a transformer based design. The alternating input voltage to the board is obtained from the secondary of a mains transformer, which ensures that the DC input to the regulator is at least 3 V higher than the required output voltage at the maximum output current. It goes without saying that the transformer is preferably a toroidal type.

Circuit description

Figures 3a and 3b show the circuit diagram of the mains section, and the DC power supply, respectively. The alternating voltage from the secondary winding is applied to the respective inputs on the supply board, while the centre tap is connected to ground. The unregulated input voltage, U_i, for the L4960 is supplied by a full-wave rectifier circuit composed of two 3 A diodes Type 1N5404, D_1-D_2, and an electrolytic reservoir capacitor, C_1. Network R_1-C_3-C_4 defines the gain of the closed regulation loop. A second network, C_2-R_2, is dimensioned for an oscillator frequency of about 100 kHz. The function of capacitor C_5 is twofold: it defines the period of the soft start ramp (see Fig. 2a), as well as the average short-circuit current. The feedback input of the regulator is connected to the junction of output voltage divider R_3-R_4.
The output voltage, U_o, of the L4960 is calculated from

$U_o = 5.1[(R_3 + R_4)/R_3]$ assuming that $U_i - U_o \geqq 3$ V.

Remember that the minimum value of U_i is 9 V. A fixed output voltage of 5.1 V (±4%) is obtained when R_3 is omitted, and R_4 replaced with a wire link. When R_3 has the fixed value of 5K6, R_4 alone determines the output voltage:

$U_o = 9$ V: $R_4 = 4K28$
$U_o = 12$ V: $R_4 = 7K58$
$U_o = 15$ V: $R_4 = 10K87$
$U_o = 18$ V: $R_4 = 14K16$
$U_o = 24$ V: $R_4 = 20K75$

These resistor values are, of course, theoretical, and require ascertaining in practice. The output voltage is readily

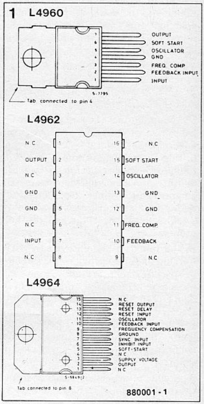
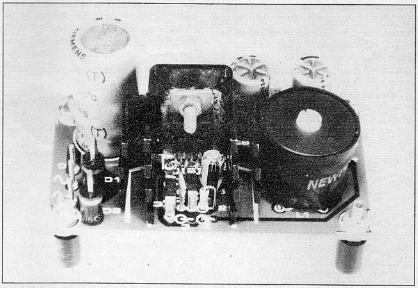


Fig. 1. Pin-outs of the integrated switch mode regulators in the L496X series from SGS Ates.



A prototype of the switch mode power supply. Note that this is set up for $U_o = 5.1$ V, since R_4 is a wire link, and R_3 is omitted.

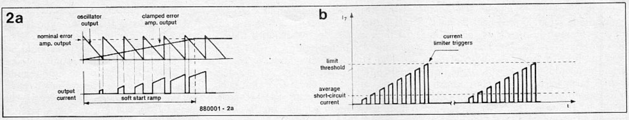


Fig. 2. Operation of the soft start (a) and current limit (b) circuits in the L4960.

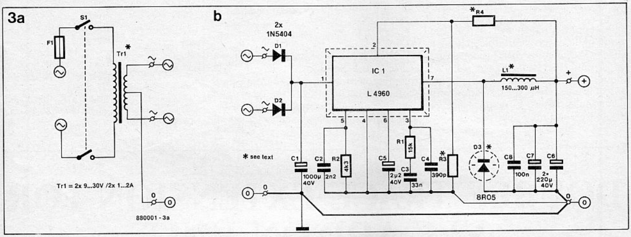


Fig. 3. Circuit diagram of the mains section (a) and the switch mode power supply (b).

Parts list

Resistors (±5%):
R1 = 15K
R2 = 4K3
R3;R4 = dimension as required for *U*o; see text

Capacitors:
C1 = 1000µ; 40 V; radial (pitch 7.5 mm)
C2 = 2n2
C3 = 33n
C4 = 390p
C5 = 2µ2; 40 V; radial (pitch 2.54 mm)
C6;C7 = 220µ; 40 V; radial (pitch 5 mm)
C8 = 100n

Semiconductors:
D1;D2 = 1N5404
D3 = 8R05* (SGS-Ates) or BYV28 (Mullard)
IC1 = L4960* (SGS-Ates)

* SGS-Ates (UK) Limited • Planar House • Walton Street • Aylesbury HP21 7QJ. UK based distributors are listed on Infocard 508:

Inductor:
L1 = 150. . .300µH toroid suppressor, e.g. Newport 1400/11/3 or Siemens B82500-B-A10 (axial). Home made: approx. 60 turns of Ø1 mm. enamelled copper wire on a suitably rated Ø15 – 20 mm ferrite core.

Miscellaneous:
TO220 style heat-sink.
TO220 style mica washer and bush.
Tr1 = toroidal mains transformer with centre tap; ratings as required (see text). E.g. ILP series: Jaytee Electronic Services • 143 Reculver Road • Beltinge • Herne Bay • Kent CT6 6PL. Telephone: (0227) 375254.
PCB Type 880001 (see Readers Services page).

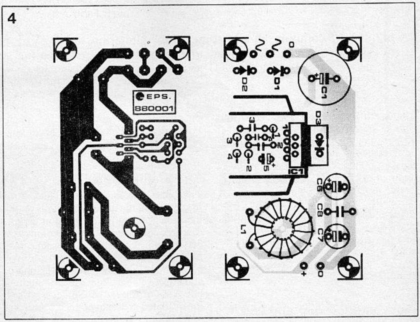


Fig. 4. The printed circuit board for the compact SMPSU.

made variable by fitting R_3 = 6K8 and replacing R_4 with a 25K potentiometer. Power diode D_3 is included as a safety measure. This fast rectifier limits the negative potential at the input of choke L_1 to a safe –0.6 to –1 V when the output transistor in the regulator is switched off. In the absence of D_3, the voltage at pin 7 would increase dangerously to several volts below the ground potential. Choke L_1 is an essential part in the L-C network for noise and ripple suppression at the output of the supply.

Construction

The compact printed circuit board for the SMPSU is shown in Fig. 4. The completion is extremely straight-forward. Start off by selecting resistors R_3 and R_4 as explained above. Fit the components in the centre, $R_1 \ldots R_4$ inclusive and $C_2 \ldots C_5$ inclusive. Prior to soldering onto the board, regulator IC_1 and power diode D_3 are bolted back to back onto a common heat-sink as shown on the component overlay. Do not forget to keep the heat-sink electrically insulated from the metal tab of D_3 with the aid of a thick mica washer and a plastic bush. It is possible to use the Type BYV28 diode in position D_3. This device is housed in an axial SOD64 enclosure, however, and requires a different mounting method than the TO220 style 8R05 from SGS. The BYV28 is mounted upright, but the anode lead is not bent down until is has been soldered to a cable eye. The eye is then insulated and fitted onto the heat-sink as detailed above. Whatever diode or mounting system is used, check the insulation with a continuity tester! Push the leads of IC_1 and D_3 into the respective holes until the heat-sink rests securely onto the board surface. Solder the leads and cut off their excess lengths. Now fit the remaining components, L_1, C_1, C_6, C_7, C_8, D_1 and D_2. Be sure to observe correct polarization of the diodes and the electrolytic capacitors. Great care should be taken to avoid any likelihood of a short-circuit between the winding on the choke core and the heat-sink for the regulator. It is recommended to secure L_1 with the aid of a central nylon bolt and nut.

Testing

Check the position, insulation and orientation of all the parts on the board before connecting this to the secondary of the mains transformer. It should be noted that the supply requires a load at all times for proper operation. When the SMPSU is fed with 30 VAC, and loaded with 2 A at an output voltage of 5 V, the temperature of the heat-sink should not exceed about 60 °C at room temperature. The efficiency of the supply under these conditions is approximately 68%. With a load of 2 A, the efficiency increases from 80% at $U_o = 10$ V, 85% at $U_o = 15$ V, to 87% at at $U_o = 25$ V. *Gb*

References:

[1] Switch mode power supplies, *Elektor India*, November 1987.
[2] High-current switching regulator IC simplifies supply design, *Elektor India*, November 1987.

DOUBLE TRACE EXTENSION FOR VLF ADD-ON UNIT

by E Fano

A handful of components and some minor alterations to the VLF add-on unit for oscilloscopes enable this popular unit to be used for two-channel measurements.

Thanks to its versatility, low cost, and ease of construction and use, the VLF add-on unit for oscilloscopes published in reference [1] has become one of the most popular construction projects featured in *Elektor Electronics*. The following description shows that the circuit is readily modified to achieve two-channel operation on a single-beam oscilloscope. The required modification and the extension circuit are useful for many applications involving the simultaneous analysis of 2 slowly varying quantities.

Input multiplexing and 256 bytes more

In the original design of the VLF storage unit, address lines A8 to A10 incl. of RAM IC_2 are kept permanently logic low. This means that only the first 256 of the available 2048 programmable locations in the RAM are used for storage of converted data. The idea behind the present extension is to drive address line A8 with a signal that creates an additional data block of 256 bytes. This block is written to during every second display—conversion cycle, and can thus hold the digitized data for a second input channel. The input signal for opamp IC_1 is, of course, multiplexed accordingly.

The modifications

The bold lines and the shaded area in Fig. 2 give all the necessary details on the modifications and the extension circuit. It is recommended to cut the connection between pins 23 and 22 of the socket that holds RAM IC_2. This modification is performed at the track side of the board, and effectively insulates pin 23—address line A8—of the RAM. Solder a wire to the insulated area that connects to socket pin 23, and run it to pin 3 of IC_{10b} (= output 1QA). Construct the input multiplexing circuit in the shaded area on a small piece of prototyping board, and connect it to the VLF storage unit as indicated by the bold lines. The electronic switches in the 4066 toggle on each pulse from output 1QA. This arrangement ensures that the correct data, i.e., the measurement values for each channel, are stored in the relevant 256 byte area in the RAM. Zener diodes D_A and D_B protect the inputs of the 4066 against overvoltages. To prevent distortion of the displayed image, the signal

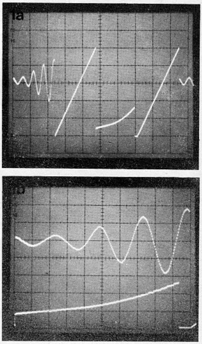


Fig. 1 Output waveform of the 2-channel storage unit using incorrect (a) and correct (b) trigger settings on the oscilloscope.

2

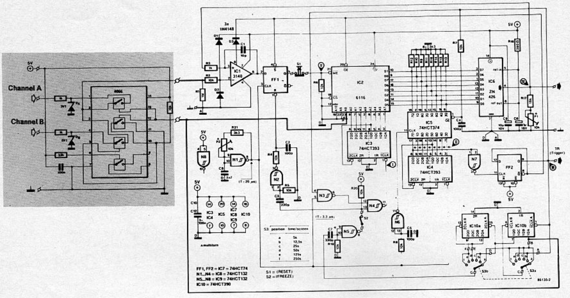


Fig. 2 Circuit diagram of the complete 2-channel unit. The modifications are shown in bold lines, the extension in the shaded area.

applied to input B may not go negative. Figures 1a and 1b illustrate the effect obtained with the modified and extended VLF storage unit.
Finally, some constructors have reported the absence of count pulses on pin 7 of IC_{10} on selecting display range **b** (12.5 s). This effect is probably due to parasitic capacitance blocking the decimal counter, and may be remedied by fitting a 33 kΩ series resistor on the TRIGGER output line to the oscilloscope. This resistor also protects the output of FF_2 against short-circuits on the TRIGGER output. Th

References:

[1] *VLF add-on unit for oscillloscopes.* Elektor India, March 1987.

SOFTWARE UPDATE FOR μP CONTROLLED FREQUENCY METER

The software for the Elektor microprocessor controlled frequency meter (see reference[1]) can be updated as shown here to enable selecting triggering on the leading or trailing edge of pulses when the meter is set to the *event count* mode. The addition to the existing program ensures a stable readout when a sawtooth-like input signal is applied to the meter, because triggering can take place on the fast rising edge.
As from now, the EPROM for the project, ESS536N, contains the update.

Reference:

[1] *Microprocessor controlled frequency meter. Elektor India*, February 1985.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$E578  JSR   $EE90    20 90 EE       $EEB3  LDAIM  $40      A9 40
                                     $EEB5  AND    $B4      25 B4
$E593  JSR   $EE90    20 90 EE       $EEB7  EORIM  $40      49 40
                                     $EEB9  ASLA            0A
$E5DC  JSR   $EEA0    20 A0 EE       $EEBA  ORA    $0700    0D 00 07
                                     $EEBD  RTS             60
$EE90  JSR   $EEB0    20 B0 EE
$EE93  JSR   $E528    20 28 E5
$EE96  RTS            60             ********* Checksum: ***********

$EEA0  JSR   $EEB0    20 B0 EE       for EPROM ESS531N:
$EEA3  JSR   $E547    20 47 E5       $E811                  1B
$EEA6  RTS            60
                                     for EPROM ESS536N:
$EEB0  STA   $0700    8D 00 07       $E811                  1A
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SYNCHROTRON X-RAYS REVEAL HOW ICE FLOWS

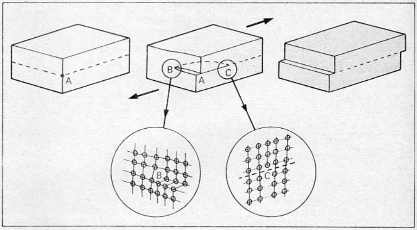
by Dr Robert Whitworth, Department of Physics, Birmingham University

Ice covers a great deal of the Earth's surface. Understanding the way it flows is important for many practical purposes such as exploiting oil reserves and helping the engineer in an ice-bound environment. An ice physics group at Birmingham University is employing a powerful research tool, the synchrotron source of X-radiation at the UK Science and Engineering Research Council's Daresbury Laboratory, to reveal detail of the flow mechanism of ice in a way not previously possible. Ice has been found to be an especially suitable material for study by this means and the group's findings promise to yield new insights into crystalline materials.

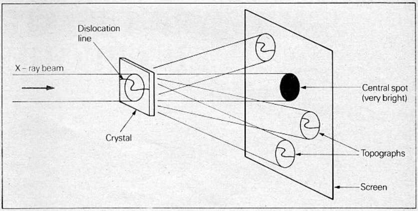
Everyday experience tells us that pieces of ice are brittle. Yet glaciers, large masses of ice, flow down the sides of mountains. In the polar regions huge sheets of ice flow out towards the oceans. The significance of such flow is brought home when something unusual happens as, for example, when the Hubbard Glacier in Alaska advanced rapidly during 1986 and blocked an inlet from the sea.

Engineers who work in the ice-bound regions of the world erecting buildings or drilling for oil have a great interest in the mechanical properties of ice, while ice physicists seek to understand the fundamental principles of its behaviour. With ice, or any other solid, there is still a great deal to be done before we can answer the question "Given the crystalline structure of a material and the properties of a single molecule, how fast will the material deform when a stress is applied to it?" At that point the problems of engineering and of physics interact and progress in either field can be of benefit to the other.

We can tell from the regular forms of snowflakes or the patterns formed by frost that ice is crystalline. This means that the molecules within it are arranged in a regular pattern. Bulk ice consists of many crystals or grains of different orientation, all joined together to form a solid mass. When such polycrystalline ice is deformed, several processes may occur. With each grain, layers of molecules may slide over one another; this is known as *slip*. In addition, grains may move relative to their neighbours. During deformation the structure suffers damage, which can be annealed out by the diffusion of molecules or by the nucleation and growth of new grains. These processes occur in all crystalline materials, but their relative importance depends on the material and on the temperature. The basic process is slip; but when ice is close to its melting point the other processes are important, too.



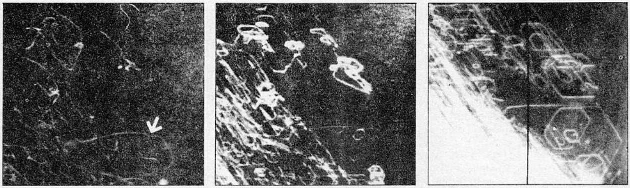
The process of slip by which plastic deformation occurs in crystals. The original block at the left is deformed to the shape on the right by one horizontal layer of atoms slipping over another by the spacing between two atoms. This does not take place all at once: in the intermediate state shown here, slip starting at A has reached the broken line BC. This is called a dislocation line and is a region of distortion in the crystal. The deformation of crystals occurs by the movement of such lines.



Formation of images of a crystal by X-ray topography using the beam from the Synchrotron Radiation Source. Because the beam is highly parallel, each point on the crystal diffracts the X-rays to the corresponding point in each of the diffraction spots formed on the film.

Dislocations

It is a little over 50 years since it was realized that one layer of a crystal cannot slip over another as a rigid whole. If we imagine that slip over one atomic spacing starts at a corner, for example point A in the first diagram, and continues up to the line BC, this line marks a region of distortion in the crystal. It is called a *dislocation line* or, for short, just a *dislocation*. Arrangements of the atoms near B and C are then as illustrated. The plastic deformation of a single crystal takes place through the



Three topographs from a sequence showing the movement and multiplication of dislocations during the plastic deformation of a single crystal of ice at −20 °C. These illustrations are negative prints, so dislocations appear bright against a dark background. The width of the region shown is 4 mm on the crystal.

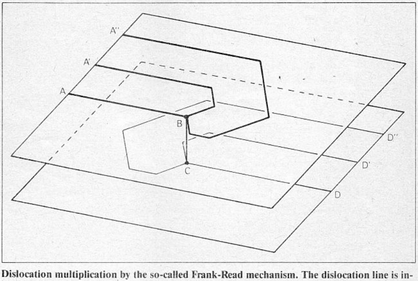
movement of these dislocation lines. How much stress is required to move them and the way in which they move have been extensively studied in metals and many other materials: the most powerful technique for observing dislocation lines is transmission electron microscopy. A limitation of this technique, however, is that the samples have to be very thin foils held in a vacuum, and it has so far proved impossibly difficult to study the properties of dislocations in ice in this way.

A different technique, which has in the past been used successfully to observe the dislocations in ice, is known as X-ray topography. Great improvements to this technique have recently been achieved through the use of X-rays from a synchrotron radiation source. By using the source at the UK Science and Engineering Research Counsil's Daresbury Laboratory we have been able to investigate the motion of dislocations in crystals of ice several millimetres in size in a degree of detail that has not previously been possible.

The Synchrotron Radiation Source is a large installation in which a beam of electrons with an energy of 2 GeV (gigaelectronvolts) is bent by magnets to circulate in an orbit of diameter 30 m. As it does so it emits intense electromagnetic radiation in the plane of the orbit, with a spectral range from infra-red to X-rays. When the X-ray beam falls on a suitably oriented single crystal, as shown in the second diagram, the crystal diffracts the X-rays to produce a number of beams in accordance with Bragg's law of diffraction. When the beams fall on a screen behind the crystal they form spots. In topography experiments at Daresbury the X-ray beam travels 80 m before it reaches the crystal, so it is virtually parallel. Because of this, every point on each diffracted spot corresponds to a particular position in the crystal. However, the diffraction from any point where the crystal is distorted will be slightly altered in such a way as to produce contrast at the corresponding point in the diffraction spot. In our experiments the diffraction spots are recorded on photographic film, thereby providing images of the crystal known as topographs. Dislocations are clearly visible within them, usually as dark lines. A sequence of such topographs taken while the crystal is under stress reveals the motion of dislocations as the crystal deforms. Compared with a normal X-ray source the synchrotron radiation beam is very intense and exposure times are comparatively short (typically 15 s). This makes proper dynamic experiments a realistic proposition for the first time.

Multiplication

Crystals used in these experiments must be of very high quality because the initial density of dislocations has to be low enough for them not to obscure one another in the topographs. Large, single crystals are specially grown in Birmingham for the experiments. In the course of deformation, the density of dislocations increases, as seen in the series of topographs making up the third illustration. This increase is essential to the process of deformation. The dislocation line is the boundary on the slip plane between the region which has slipped and the region which has not; the rate at which the boundary moves corresponds to the rate of deformation, but if all the dislocations that were present to begin with merely moved across their slip planes and out of the surface the deformation would stop. New dislocation lines are created by a process of multiplication, the mechanism of which was first suggested in 1950 by F.C. Frank of Bristol University and W.T. Read of Bell Telephone Laboratories. If a dislocation line does not lie entirely on one slip plane, but makes a step from one plane to another, the dislocation lines on the separate planes form a spiral around the step as shown in the fourth illustration. This means that the dislocations do not pass out of the crystal but con-



Dislocation multiplication by the so-called Frank-Read mechanism. The dislocation line is initially at ABCD, with the sections AB and CD lying on different slip planes. Under stress the step BC does not move, but as AB and CD move forward to A'B and CD' and then to A''B and CD'' they generate spirals around B and C. Seen in projection on the slip plane it appears as if loops are being generated from the point corresponding to BC. These are the 'loops' seen in the lower right of the sequence of topographs.

tinuously grow longer. Near the centre of the spiral, slip amounts to as many atomic spacings as there are turns in the spiral.
In the sequence of topographs, a pair of opposite spirals can be seen developing in the lower right-hand corner. The position of the step from which they originate is marked by the arrow in the first topograph. Often, the multiplication is more complicated as is shown in the topograph on the front page. When we recall that the dislocation line is the boundary of the region which has slipped, it is remarkable how convoluted the boundary can become. These topographs of ice are some of the clearest images of dislocations moving in crystals of this size ever obtained in any material; the study promises to yield an understanding of the processes of dislocation multiplication in bulk samples which will be significant in the understanding of other materials, too.
The crystal structure of ice has a hexagonal axis of symmetry which is easily seen in the shapes of snow flakes, and deformation of single crystals is know to occur almost entirely by the slip of planes, called the basal planes, lying

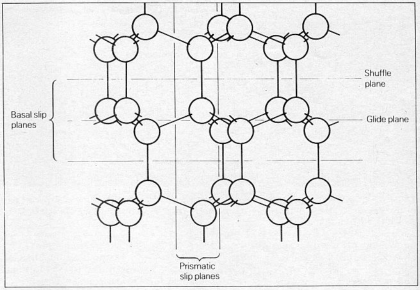
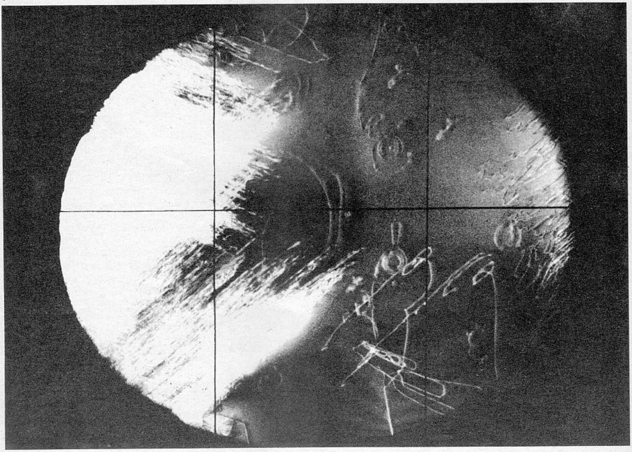


Diagram of the crystal structure of ice. The circles represent water molecules, each of which is linked to four others by hydrogen bonds. The hexagonal axis of symmetry is vertical and the normal slip planes (the basal planes) are horizontal. There are two sets of such planes, the glide set and the shuffle set, between which slip may occur. Possible prismatic slip planes are shown as vertical. As in the case of basal slip, the slip direction on these prismatic planes is horizontal, approximately into or out of the plane of the diagram.



This image shows part of a single crystal of ice after a small amount of plastic deformation. It is an X-ray topograph, formed by diffraction of X-rays from the Synchrotron Radiation Source at the UK Science and Engineering Research Council's Daresbury Laboratory. Deformation takes place through the movement of defects in the crystal known as dislocations, seen here as bright lines. Dense bands of them are spreading from the left-hand side and are just beginning to do so from the right, generated by a process of dislocation multiplication which can be seen happening more clearly in the formation of the tangled loops at the lower right. The spiral to upper right of centre was formed by diffusion of defects prior to deformation. Taken by scientists from Birmingham University, the topograph is of an area of crystals one centimetre across.

perpendicular to this axis. The final diagram of the structure shows that there are two kinds of basal planes between which slip might occur, in two sets called the glide set and the shuffle set. It has not yet been possible to find out by experiment which set slips. By comparison with other materials of similar structure, and for theoretical reasons, the glide set seems the more likely. From the diagram it is far from obvious why ice should not deform just as easily by slip on vertical planes known as prismatic planes. But experiment shows that it takes about 50 times more stress to deform ice in that way.

To deform a polycrystalline mass of ice, slip within the grains must take place in more than one set of parallel planes if the grains are not to come apart at the boundaries. This is the main reason why polycrystalline ice is stronger than a single crystal. From our topographs we have found that, in certain circumstances, dislocations on prismatic planes move as fast as or faster than those on basal planes. This comes as a surprise to anyone who knows how difficult it is to deform ice along the prismatic planes, and it looks as though the preference for basal slip arises not because it is difficult to move dislocations along other planes but because multiplication is easier in the basal plane.

Another effect that is important potentially is that the strength of ice is very sensitive to the presence of minute traces of certain impurities. Some years ago, Dr S.G. Jones ans Dr J.W. Glen in our laboratory found that one part in a million of hydrogen fluoride reduces the stress needed to deform a single crystal of ice to as little as one-quarter of normal. It may be significant that small additions of hydrogen fluoride also produce large changes in the electrical properties. We hope to use X-ray topography to investigate these effects, and so learn more about the processes which limit the rate of movement of the dislocations.

A proper understanding of the physics governing dislocation movement in a material is necessary for a theoretical interpretation of the strength of that material. Metallurgists have made great use of knowledge gained from electron microscopy in developing new alloys for use in aircraft, nuclear reactors and elsewhere under other extreme conditions. A similar understanding of the physics of ice is needed to predict or modify the behaviour of ice in the environment. It is even more necessary when we wish to forecast how ice will behave in less familiar conditions. For example the recent discovery that some of the moons of the planets Jupiter and Saturn are composed mainly of ice has led to questions about how ice would deform on a geological time scale at high pressures and at low temperatures.

Transistor letter symbols

Bipolar

C_{cb}, C_{ce}, C_{eb} Interterminal capacitance (collector-to-base, collector-to-emitter, emitter-to-base).

C_{ibo}, C_{ieo} Open-circuit input capacitance (common-base, common-emitter).

C_{ibs}, C_{ieo} Short-circuit input capacitance (common-base, common-emitter).

C_{obo}, C_{oeo} Open-circuit output capacitance (common-base, common-emitter).

C_{obs}, C_{oes} Short-circuit output capacitance (common-base, common-emitter).

C_{rbs}, C_{res} Short-circuit reverse transfer capacitance (common-base, common-emitter).

f_{hfb}, h_{fe} Small-signal short-circuit forward current transfer ratio cutoff frequency (common-base, common-emitter).

f_T Transition frequency or frequency at which small-signal forward current transfer ratio (common-emitter) extrapolates to unity.

G_{pb}, G_{pe} Small-signal insertion power gain (common-base, common-emitter).

G_{tb}, G_{te} Small-signal transducer power gain (common-base, common-emitter).

h_{FB}, h_{FE} Static forward current transfer ratio (common-base, common-emitter).

h_{fb}, h_{fe} Small-signal short-circuit forward current transfer ratio (common-base, common-emitter).

h_{ob}, h_{oe} Small-signal open-circuit output admittance (common-base, common-emitter).

h_{rb}, h_{re} Small-signal open-circuit reverse voltage transfer ratio (common-base, common-emitter).

I_B, I_C, I_E Current, d.c. (base-terminal, collector-terminal, emitter-terminal).

I_b, I_c, I_e Current, r.m.s. value of alternating component (base-terminal, collector-terminal, emitter-terminal).

i_B, i_C, i_E Current, instantaneous total value (base-terminal, collector-terminal, emitter-terminal).

I_{BEV} Base cutoff current, d.c.

I_{CBO} Collector cutoff current, d.c., emitter open.

$I_{E1E2(off)}$ Emitter cutoff current.

I_{EBO} Emitter cutoff current, d.c., collector open.

$I_{EC(ofs)}$ Emitter-collector offset current.

I_{ECS} Emitter cutoff current, d.c., base short-circuited to collector.

P_{ib}, P_{ie} Small-signal input power (common-base, common-emitter).

P_{ob}, P_{oe} Small-signal output power (common-base, common-emitter).

r_b, C_c Collector-base time constant.

$r_{CE(sat)}$ Saturation resistance, collector-to-emitter.

$r_{e1e2(on)}$ Small-signal emitter-emitter on-state resistance.

R_{th} Thermal resistance.

T_j Junction temperature.

t_d Delay time.

t_f Fall time.

t_{off} Turn-off time.

t_{on} Turn-on time.

t_p Pulse time.

t_r Rise time.

t_s Storage time.

t_w Pulse average time.

U_{BB}, U_{CC}, U_{EE} Supply voltage, d.c. (base, collector, emitter).

U_{BC}, U_{BE}, U_{CB}, U_{CE}, U_{EB}, U_{EC} Voltage, d.c. or average (base-to-collector, base-to-emitter, collector-to-base, collector-to-emitter, emitter-to-base, emitter-to-collector).

u_{be}, u_{be}, u_{cb}, u_{ce}, u_{eb}, u_{ec} Voltage, instantaneous value of alternating component (base-to-collector, base-to-emitter, collector-to-base, collector-to-emitter, emitter-to-base, emitter-to-collector).

$U_{(BR)CBO}$ (formerly BV_{CBO}) Breakdown voltage, collector-to-base, emitter open.

y_{fb}, y_{fe} Small-signal short-circuit forward-transfer admittance (common-base, common-emitter).

y_{ib}, y_{ie} Small-signal short-circuit input admittance (common-base, common-emitter).

y_{ob}, y_{eo} Small-signal short-circuit output admittance (common-base, common-emitter).

y_{rb}, y_{re} Small-signal short-circuit reverse transfer admittance (common-base, common-emitter).

Unijunction

$I_{B2(mod)}$ Interbase modulated current.

I_{EB_2O} Emitter reverse current.

I_p Peak-point current.

I_v Valley-point current.

r_{BB} Interbase resistance.

T_j Junction temperature.

t_p Pulse time.

t_w Pulse average time.

$U_{B_2B_1}$ Interbase voltage.

$U_{EB_1(sat)}$ Emitter saturation voltage.

U_{OB_1} Base-1 peak voltage.

U_p Peak-point voltage.

U_v Valley-point voltage.

Field Effect

b_{fs}, b_{is}, b_{rs} Common-source small-signal (forward transfer, input, output, reverse transfer) susceptance.

C_{ds} Drain-source capacitance.

C_{du} Drain-substrate capacitance.

C_{iss} Short-circuit input capacitance, common-source.

C_{oss} Short-circuit output capacitance, common-source.

C_{rss} Short-circuit reverse transfer capacitance, common source.

$\bar{F}$ or F Noise figure, average or spot.

g_{fs}, g_{is}, g_{os}, g_{rs} Signal (forward transfer, input, output, reverse transfer) conductance.

G_{pg}, G_{ps} Small-signal insertion power gain (common-gate, common-source).

G_{tg}, G_{ts} Small-signal transducer power gain (common-gate, common-source).

$I_{D(off)}$ Drain cutoff current.

$I_{D(on)}$ On-state drain current.

I_{DSS} Zero-gate-voltage drain current.

I_G Gate current, d.c.

I_{GF} Forward gate current.

I_{GR} Reverse gate current.

I_{GSS} Reverse gate current, drain short-circuited to source.

I_{GSSF} Forward gate current, drain short-circuited to source.

I_{GSSR} Reverse gate current, drain short-circuited to source.

I_n Noise current, equivalent input.

$Im(y_{rs})$, $Im(y_{is})$, $Im(y_{os})$, $Im(yrs)$.

I_s Source current, d.c.

$I_{S(off)}$ Source cutoff current.

I_{SDS} Zero-gate-voltage source current.

$r_{ds(on)}$ Small-signal drain-source on-state resistance.

$r_{DS(on)}$ Static drain-source on-state resistance.

$t_{d(on)}$ Turn-on delay time.

$U_{(BR)GSS}$ Gate-source breakdown voltage.

$U_{(BR)GSSF}$ Forward gate-source breakdown voltage.

$U_{(BR)GSSR}$ Reverse gate-source breakdown voltage.

U_{DD}, U_{GG}, U_{SS} Supply voltage, d.c. (drain, gate, source).

U_{DG} Drain-gate voltage.

U_{DS} Drain-source voltage.

$U_{DS(on)}$ Drain-source on-state voltage.

U_{DU} Drain-substrate voltage.

U_{GS} Gate-source voltage.

U_{GSF} Forward gate-source voltage.

U_{GSR} Reverse gate-source voltage.

$U_{GS(off)}$ Gate-source cutoff voltage.

$U_{GS(th)}$ gate-source threshold voltage.

U_{GU} Gate-substrate voltage.

U_n Noise voltage equivalent input.

U_{SU} Source-substrate voltage.

y_{fs} Common-source small-signal short-circuit forward transfer admittance.

y_{is} Common-source small-signal short-circuit input admittance.

y_{os} Common-source small-signal short-circuit output admittance.

SIR CLIVE SINCLAIR: SUPER ELECTRONICS ENTREPRENEUR

by Martin Ince

As both a leading developer of original ideas in the electronics industry and a businessman who pioneered mass marketing of his products well below the prices of his rivals, Sir Clive Sinclair has firmly established himself as the best known Britain in his field today.

A public opinion poll a few years ago in the United Kingdom placed him in a list of the top ten scientists of all time alongside Leonardo da Vinci and Albert Einstein, although he has no professional academic background and did not even go to university. After over 25 years in business, he is still producing ideas for new electronic products and launching the firms to manufacture them.

To achieve this, he often drives research teams to turn his ideas into products ahead of the competition worldwide. But his commercial origins lie in technical fields far removed from the wafer scale chips and portable telephones that now dominate his business plans.

Early commercial pursuits

It is noteworthy that his early days offer little clue that he would become the one individual associated in many people's minds with the spread of high technology products into everyday life. He left school at 17, with a less than glittering academic record, and before starting his career as an independent businessman, he was employed on a magazine for amateur electronics enthusiasts, *Wireless World*.

The publication is famous throughout electronics and communications, and for publishing Arthur C. Clarke's 1945 futuristic article on geostationary communications satellites—creations that now dominate international telecommunications.

His first company, Sinclair Radionics, opened its doors in 1962 and in many ways marked the start of his career as an electronics entrepreneur. Its business was to supply kits to radio amateurs who wanted to make their own equipment, but had previously had to go to a variety of sources for the necessary parts.

The idea was ingenious and worked comparatively well, but lacked the other key ingredient of Sinclair's business projects in recent decades—the possibility of a mass market for the product.

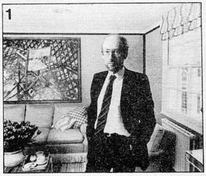


Fig. 1. Sir Clive Sinclair, electronics genius.

There simply are not millions of people wanting to build their own radios.

However, there was a potential mass market for his next generation of products—a range of cheap calculators and digital watches designed (in another Sinclair hallmark) to make sophisticated equipment available at well below the prices of rival suppliers.

Low cost computers

While some satisfied users of Sinclair calculators are still to be found in the United Kingdom, the increasing competition from Far Eastern and other major suppliers of cheap consumer electronics soon meant that these products—commercial successes when they were launched—ceased to be major money-spinners. But by now his attention was on another market—that for computers—where his name would be made on a wider scale.

At this stage, his tactic was to produce a computer for under £100—vastly less than the price of the Apple machines then sweeping the world. The result of Sinclair's computer development programme was a series of machines of increasing power, starting with the ZX80 and proceeding through the ZX81, the Spectrum (regarded by the experts as the best Sinclair computer) and the QL (for Quantum Leap).

Fig. 2. Sir Clive Sinclair and his miniature television receiver.

Sir Clive's vital role in British electronics has been to open up markets for sophisticated goods at low prices, sometimes in a way that has benefited competitors more than himself.

His own computers were not best-sellers in the long term, and his interests in this field have now been sold to Amstrad, the firm that has popularized home computing and word processing in the United Kingdom. Another Sinclair product, the C5 electric car, which is no longer on the market, was even less of a success, this time because of technical problems with the vehicle itself.

High technology telephones

But he shows no signs of bowing out of the high technology business. He is a director and part owner of a new firm, Shaye Communications, which plans a new, miniaturized form of portable telephone for business and private users. This time the aim is to produce a portable telephone at about half the size and a fifth of the price of existing machines, with a retail price of about £200.

The idea is to manufacture a telephone that can be used via a network of public access points, providing a route into the general network and therefore offering many advantages over cellular telephony. Because Britain has an acute shortage of radio spectrum space, the telephones would economize on radio spectrum space and would be less prone to interference and eavesdropping than existing cellular phones.

Moreover, Sinclair recently launched his latest computer, the Z88, a cheap laptop machine costing about £230, weighing less than 4 kg and under 3 cm thick. It cannot be sold under his name, however, because Amstrad now has the rights to call a computer a sinclair. Instead, it is sold by Sir Clive's new firm, the Cambridge Computer Company. Despite missing out on university himself, Sinclair has long found Cambridge a

congenial site for his high technology companies.
He also has plans to tackle the highest levels of computer technology via a new firm called Anamartic, which aims to develop a wafer scale electronic memory. British banks have put several million pounds sterling behind the company, which proposes to produce a practical memory on which the chips used are connected on a single wafer, allowing more speed and scope than existing memory devices.

Same Sinclair thinking

Sinclair must hope that Anamartic will live up to its name, which comes from the Greek for "faultless". His idea of establishing a British presence in wafer scale memory technology is undoubtedly ambitious. The technology is one that other British manufacturers would probably choose to import from Japan or elsewhere, but he did run Europe's largest calculator manufacturer at a time when that area was thought to be beyond the scope of Britain's own electronics industry.
Anamartic bears clear signs of traditional Sinclair thinking. If the technology developed at his Metalab development centre in Cambridge works, it will provide a breakthrough in cost and simplicity, which will allow computers to be yet cheaper, smaller and more available.
The first market Anamartic wants to tackle is business automation, including manufacturers of office workstations. But anyone who knows Sir Clive's taste for taking technology to consumer markets cannot doubt that this will be his next stop if it proves a success.

THE RISE AND RISE OF THE MICRO

by C H Freeman

California's 'Silicon Valley', that conglomerate of many semiconductor and electronic equipment manufacturers, has its roots in 'the Fairchild takeover'. Fairchild Semiconductor had been bought out in 1959 by Fairchild Camera and Instrument. With the takeover there came the implementation of new, rigid management structures. The managers of the old style Fairchild found themselves the middle-management of the 'new' company, and became dissatisfied and disillusioned. Resignations began. Those who resigned began to set up their own semiconductor manufacturing companies, companies such as the (now) familiar Signetics, Intersil et al emerged. In total, about 50 IC companies have their roots in Fairchild.

Birth of the microprocessor

It was in 1968 that Robert Noyce, general manager at Fairchild, left the company to co-found Intel. Noyce had been one of the founding fathers of Fairchild Semiconductor in 1957. He had been intimately involved with semiconductor technology for most of his professional life and had acquired a very considerable expertise in that field. It was Noyce who pioneered research and development of the monolithic integrated circuit at Fairchild Semiconductor, quite literally from sketchbook to production line in the early 1960s. Such was his reputation that venture capital flooded into the newly-founded Intel with Noyce's announcement that the company intended to specialize in memory chips; very much a growth sector in the IC market of the day.
During the next two years, Intel's reputation grew, along with the sophistication of its products. By 1970 Intel had introduced a 256 bit RAM, stimulating in earnest the switch from magnetic core to IC main memory. It was in the summer of 1969, however, that Intel were approached by Busicom, a now-defunct Japanese calculator manufacturer, to develop a set of chips for a new line of programmable electronic calculators. Intel had recently announced the development of new IC manufacturing techniques for making 2,000 transistor chips and Busicom hoped Intel would be able to make even more sophisticated devices.

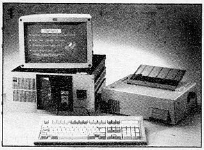


Fig. 1. The IBM 7351 Computer. ***Photograph courtesy of PPM Instrumentation.***

The Busicom engineers had prepared preliminary designs which called for 12 chips, performing logic and memory functions, in each calculator. By varying the 'program' held in the ROM chips, a whole line of calculators with different capabilities and functions could be produced. Intel assigned Marcian E. Hoff, Jr to the project. Hoff studied the Busicom designs carefully and concluded that, whilst technically feasible, they would be too complicated to produce in a cost-effective manner; there were simply too many chips per device. The more Hoff considered the problem, the more he became convinced that one particular route led to the solution of the problem. Along that route lay the concept of a general-purpose logic chip which, like the central processor of a computer, could perform any logical task. Such a micro-sized processor—a *microprocessor* — would be programmable, acting on instructions and data held in RAM and ROM.
The advantages were clear. Busicom's calculators could now be re-designed

into cost-effective 4 chip (microprocessor, ROM, RAM and an I/O interface chip) machines, rather than the original 12 chip uneconomic devices initially mooted. As Hoff critically examined these proposals, he began to see the promises such a device held. A reduced chip count meant fewer interconnections between discrete IC's, a simpler, more flexible and powerful design specification could be issued. The most exciting prospect, however, lay in the device's programmability, and programmability meant versatility. This scheme was accepted by Busicom and in late 1970 the first microprocessor, the Intel 4004, began rolling off the production lines.

The 4004, as its title suggested, was a 4-bit microprocessor. The 4-bit architecture was, at that time, state-of-the-art stuff. A wider data bus was not technically possible at the time. This mattered little, however, as the 4-bit architecture was perfectly suited to processing single decimal digits. The other 3 chips were similarly of limited capability. The ROM, containing the calculator program, had a capacity of just 2k bits, whilst the RAM held 320 bits. The calculators were duly produced by Busicom, using the 4 Intel chips and the few months after the introduction of the calculators onto the market saw the chips prove themselves as reliable, flexible, cost-effective pieces of hardware.

The 4004 had been developed exclusively for Busicom and Intel had no marketing rights to the device whatever. The economics of the calculator business in the summer of 1971 saw Busicom ask Intel for a price cut on its chips. In exchange for this cut, Intel were to receive full marketing rights to the 4004 and its associated support chips. With the marketing rights to the chips firmly established, Intel launched the chips onto the public market in November 1971. The advertising hype used to promote the 'new' MCS-4 family belies the uncertainty behind the launch. Intel's marketing division really did have a 'fingers crossed' attitude towards sales. No one was really certain if the public would buy the devices. The first advert says much about the type of application envisaged for the MCS-4 family. To quote from the advertisement:

''MCS-4 systems provide complete computing and control functions for test systems, data terminals, measuring systems, numeric control systems and process control systems...MCS-4 systems interface easily with switches, keyboards, displays, printers, readers...''

Orders were slow. The initial sales levels attained by the 4004 were not high enough to justify further microprocessor development. It was most unlikely that the next Intel microprocessor, the 8008,

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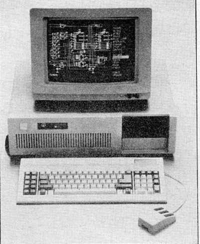

Fig. 2. Transferring schematics to PCB layouts by computer. *Photograph courtesy of Betronex Ltd.*

would have reached research stage had it not been for a CRT research project undertaken by the Display Terminal Corporation (as they were then known). Texas Instruments and Intel had entered into an agreement with DTC, the object of which was to produce a monolithic processor capable of controlling a CRT terminal.

A few months after drafting the agreement, Texas Instruments pulled out, leaving Intel to continue development alone. Intel came up with the goods: almost. The chip worked well, but slowly. Too slowly for its intended application as a CRT controller and the Intel-DTC contract was dissolved. This left Intel with an (apparently) unsaleable microprocessor on their hands; what were they to do? Almost unbelievably, the 8008 microprocessor was released on general sale in 1972 on the assumption that it would assist sales of memory chips! The Intel microprocessor research team were duly disbanded and that, it was thought, was that. However, it was

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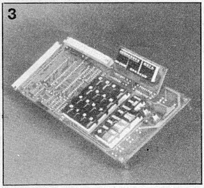


Fig. 3. *Elektor Electronics'* Junior Computer announced in May 1986 was built by thousands of computer enthusiasts all over the world.

far from being 'that'. To everyones surprise, the 8008 was a big-seller and, almost overnight, microprocessors began to be perceived in a new light: as a growth market with attendant implications of large capital returns. The changes the 8008 imbued into the semiconductor manufacturers manifested themselves in the explosion of 'me too' microprocessor manufacturers: Rockwell, Signetics, Motorola etc. all announced their intentions to market their own microprocessors. Intel, realizing they were on to a good thing, hastily re-assembled their design team and set them to work on the next processor, the 8080. The commercial desirability of software compatibility had long been realized within the industry and the 8080 was designed to be software compatible with the 8008. A year after the introduction of the 8008 the 8080 was launched to an even more enthusiastic reception. Competitors set to design and market their own processor chips in direct competition with the 8080. It is significant that the next three years saw the introduction of chips now regarded as industry standards: the 6502, the 6800, the Z80, the TMS1000 series etc.

By 1976 the microprocessor had established itself in many applications, proving itself a reliable, efficient, cost-effective component. The semiconductor manufacturers had come to accept them as a necessary and lucrative part of a manufacturing operation. The microprocessor was here to stay!

Enter the minicomputer

The late 1950s had seen the computer evolve into a useful, if difficult and expensive, tool. The computer's place in the scheme of things seemed clear; scientific research, defence depts., large automated accounts depts., educational establishments—they all found comfortable uses for their new-found computer power. The advent of time-sharing systems saw an even greater degree of computer penetration. Aside from the obvious advantages of allowing many users within a single company or organisation to simultaneously 'use' the organisations computer, a new use for time-sharing systems was spotted. Commercial time-sharing services began to appear. Customers of the service would use remote terminals to communicate with the time-sharing computer via 'phone lines, buying time on the machine on a minute-by-minute basis. By 1960 time-sharing was very much a growth sector of the computer market and was being confidently hailed as the 'way of the future'.

The big machines required to run any sort of computing operation were still costly, however: they were costly in terms of full-time operations staff needed, costly in terms of physical space and power required and, above all, costly in terms of initial outlay. In the early 1960s a new need for a breed of smaller and relatively less complex (and hence relatively inexpensive) machines was beginning to be identified. Thus it was that in 1963 the American computer manufacturers Digital introduced the PDP-8. In comparison with the mainframes of the day it was a limited machine. The PDP-8 ran just one program at a time, processed data in 12 bit words and had just 4K words of memory, but the advantages the machine offered were obvious. The PDP-8 was, physically, about the size of a large domestic freezer, did not require a legion of trained support staff and, most importantly, cost just $18,000; a fraction of the price of then available main-frame computers. The PDP-8 sold extremely well, penetrating both old and new markets. Scientists, defence and educational establishments, industrial plants and financial institutions all welcomed the new *minicomputer* with open arms. Every drop in the price of the PDP-8 captured new customers, hitherto unable to afford their very own computer power.

By the end of the '60s a firm dichotomy had been established, with the mainframe and the minicomputer occupying two different and well-defined market sectors. A measure of the impact of the mini can be gained from the fact that by 1971 at least 70 American firms were manufacturing them, with estimated sales running into many thousands of millions of dollars. The minicomputer had arrived.

Birth of the microcomputer

The development of the first microcomputer is a story that is, economically speaking, quite different from the development of the minicomputer.

The first serious, documented research into the possibility of producing a home (or personal) computer occured at Digital (again) in the early '70s. It is most probable that other companies investigated the personal computer idea also, but the Digital investigation remains the most documented experience. David Ahl joined Digital in 1969 as a market researcher. An engineer by trade, Ahl became involved in marketing the company's minicomputers to schools, colleges and other 'small' institutions. In addition to the 'regular' type of orders for machines from institutions and groups, Ahl occasionally received orders from individuals for a Digital mini. This set a train of thoughts in motion in Ahl's mind as he began to wonder if there would be a market for a simple, low cost personal computer. In 1973 Ahl moved to Digital's research and development wing, investigating (among other things) new markets for certain products. A separate engineering study was being simultaneously pursued in the R&D group, the object being to manufacture a small business computer. Ahl became interested in the project and began to eagerly investigate the marketing side whilst the engineering chaps worked on perfecting two prototypes, which were eventually persuaded into working order in early 1974. Details of these prototypes remain sketchy, but one was a 'modified computer terminal', the circuitry being constructed from discrete logic and memory chips; no microprocessors were involved in its construction. The second prototype, however, was quite a different proposition. More radical and daring in its design philosophy, this machine was a portable self-contained computer, about the size of a thick attache case, comprising a monitor, keyboard, floppy disc drive and the main processor itself. Microprocessors were incorporated in the design of this second machine. In May 1974 a management committee convened at Digital's headquarters to discuss the future of the project. The technical half of the committee were, understandably, enthusiastic. The machines worked well (aside from teething troubles with the floppy disc drive) and could be manufactured economically. The sales department, making up the other half of the committee, were far less enthusiastic. Why, it was reasoned, should educational departments buy the machines? A time-sharing computer would be much more cost-effective. Why should the ordinary householder buy them? There were no conceivable 'home' applications. In the end the salesmen won the day and the project was dropped. The computer industry, it seemed, was indifferent to the prospect of a personal computer. It mattered not that such machines were technically feasible and, indeed, could be manufactured and sold on a cost-effective basis: no market for such devices could be seen. The early development of the microcomputer thus rested squarely on the shoulders of the hobbyists — people whose primary motivation was technical rather than financial. The introduction of the Intel 8008 microprocessor, the 8 bit successor to the 4004, stimulated the interest of one Jonathan A. Titus, an electronics hobbyist. Studying the specifications of the 8008, Titus realized that the chip was powerful enough to run a microcomputer and set about designing his own such machine. By Autumn 1973 Titus had a working prototype and, wishing to share the design with other members of the hobbyist fraternity, contacted various amateur electronics periodicals, enquiring whether they would care to publish his design. The offer was finally taken up by the (American) 'Radio-Electronics' magazine—a publication firmly aimed at the hobbyist. The July 1974 edition carried a constructional article on the Mark-8 (as it had been christened) together with a parts source guide and approximate costing. The Mark-8 was a strictly limited machine. Its innards contained 256 bytes of RAM expandable up to 16K and no ROM: Titus would have had to pay significant amounts to Intel to produce ROMs to his specification. Input/output consisted of lamp and switch technology. Despite its limitations, interest in the Mark-8, and subsequent sales of the bare circuit boards, far exceeded expectations. Yet, in spite of this, Titus did not even consider forming a computer company, regarding the Mark-8 as more of an 'educational' project than a commercial proposition.

Fig. 4. A stimulating application of the microcomputer: *Mailbox Chess*, a British Telecom (Prestel) service.

The interest stimulated by the introduction of the Mark-8, coupled with Intel's newly released 8080 microprocessor, prompted a small electronics company called MITS to introduce the Altair 8800. The 8800 was designed for the American hobbyist electronics publication 'Popular Electronics'. The project was intented to be printed as a series of constructional articles in the magazine and, like the Mark-8, was aimed firmly at the hobbyist market. The basic machine was designed with expandability very much in mind. The 256 byte memory supplied with the basic kit could be expanded right up to the maximum 64k bytes possible with the 8080 processor by means of slot-in memory boards. Other peripherals, such as a CRT terminal, printer, alphanumeric keyboard and papertape reader were also on the drawing board. Combining peripherals, memory expansion boards and the 8800 itself could produce, for the first time, a *really useful*, relatively low cost system. Such a system formed the first — the very first — fully fledged personal computer on the market. The 8800 made its first appearance in the January 1975 edition of Popular Electronics and was an instant sensation. The machine was offered to readers of the magazine at a cost of $650 fully

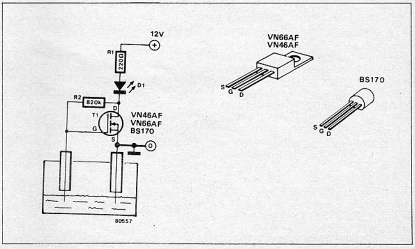
assembled and $395 in kit form. Such prices for a machine of such high specification were unheard of and orders poured into MITS, who had great difficulty in fulfilling customers orders. Customers experienced delays of up to 6 months (sounds familiar!) before delivery of their computers, and the promised peripherals did not materialize until early 1976: one year later (sounds even more familiar!). The popularity of the hardware stimulated an 8800 based software market. A BASIC interpreter was written for the machine and marketed, with success, by MITS. The 8800 can, justifiably, be said to have been the first 'real' personal computer, and its success helped fuel the belief that a significant market for personal computers might exist after all.
As interest in the Altair 8800 grew, the first 'computer clubs', run by and for amateur enthusiasts, were being formed all over America. It was at one such club in California's Silicon Valley that Stephen Wozniak, a young self-taught computer engineer, became interested in the possibility of fabricating a 'homebrew' computer. Wozniak examined the specifications of available microprocessors and concluded that the comprehensive instruction set of the newly-introduced 6502 would serve his purposes best. Wozniak set to work, writing a BASIC interpreter *before* going on to design and construct the hardware. The finished article was a single board computer with 4K of onboard RAM and circuitry to enable direct connection to a monitor. Wozniaks friend, Stephen Jobs, saw a market for the computer and tried to persuade Wozniak to enter into a business partnership with him. Wozniak, meanwhile, had demonstrated the board to a gathering of other homebrew enthusiasts and the reception had been so enthusiastic that he had approached Hewlett-Packard, his employer, and tried to interest them in manufacturing his computer. Hewlett-Packard refused, however, doubting the existence of a sufficiently large market. Jobs thought differently. He approached several potential buyers and eventually signed a contract for 100 boards at $500 each. Jobs and Wozniak went into partnership and the Apple Computer Company was born. The Apple I (as it has subsequently become known) had no keyboard, terminals, disc drives etc. and was clearly targeted at the hobbyist 'tinkerers' market. In total, Apple sold around 175 boards at $500 apiece, leading Jobs and Wozniak to consider the project a great success. So much of a success, in fact, that the pair went to work on a second machine, Wozniak taking care of technical development and Jobs looking after the business side of Apple. In october 1976 Jobs received significant help from a venture capitalist who decided that the newly-developed Apple II was just right for the mass market. With a firm business plan and significant financial backing, the Apple II went on sale in 1977. Sales of the machine rapidly grew, boosted by a hard advertising campaign, and by the end of 1977 the Apple Computer Company's annual sales were estimated to be in the region of $775 000. Next year's sales were even better and Apple were named as the fastest-growing company in American history. The software base for the machine grew rapidly, helping to fuel sales to further heights. The personal computer had arrived.
The establishment of a mass-market for the personal computer shook other manufacturers out of their complacency and, in time-honoured fashion, began to jump onto the bandwagon. From here on, market forces begin to take control and the story of further developments in the field of personal computing becomes less concerned with technical innovation and more concerned with hard economics. One further development, however, merits a brief glance. In 1981 IBM entered the fray with its PC, the machine becoming an instant success in its target area (the so-called middle-business market). With IBM sales of the PC well established, the familiar scenario of 'me-too' PC clone manufacturers, introducing machines in direct competition with IBM appears again. The resulting economic morass is a startlingly familiar cocktail of market forces.

Conclusion

With a well established trichotomy of mainframe/mini/micro the future may well see significant technical developments, but in a capitalistic economy, where market forces reign supreme, it will be the businessmen, and not the scientist, who will decide what sees the light of day. With the benefit of hindsight it is difficult to imagine that in the future technical constraints, rather than economic ones, will form the sword of Damocles over continued development. Time alone will tell.

water detector

The level of water in a water tank can be measured in various ways, some of which can of course be more complicated than others. The circuit published here lights a LED whenever the level of water drops below the electrodes. With a high water level, the FET hardly conducts or not at all, because the gate is then connected to earth and there is no voltage difference between gate and source. When the water level drops, the gate/source connection is interrupted. The gate is then at a positive potential by means of the 820 k resistor, thereby causing the FET to conduct. The LED will now light. If the reverse operation is needed, that is the LED lights when the electrodes are short circuited by the water, just connect the 'earthy' electrode in the circuit to the positive and wire R2 between gate and source.



Julian Nolan's discourse on dual-trace oscilloscopes is continued this month with reviews of the Gould OS300 and the Grundig MO20.

Part 1: dual-trace oscilloscopes (B)

Gould OS300

Gould have a high reputation for the quality and robustness of their oscilloscopes and the OS300 follows in this trend, in spite of it being the cheapest scope manufactured by Gould. The Gould range of oscilloscopes comprises real-time and digital storage units at prices well over £18,000 for a complete digital acquisition system. Gould also manufacture a wide range of other specialized electronic products such as digital chart recorders, logic analysers and emulators, etc. Gould also have available a wide range of accesories for its oscilloscopes, such as protective carrying cases, rack mounting kits and of, course, probes.

The OS300 is delivered in an easily identifiable blue/white box and is well protected by the standard polystyrene or similar cutouts which surround it. The scope is supplied with a comprehensive manual and, I believe, a mains lead (the review model was not). Since the mains connection is made via a standard IEC style socket, there is no problem should the lead supplied be lost or too short. The scope itself is quite small as far as the height and the width are concerned, although the depth is a relatively long 460 mm. It weighs only 5.8 kg. The OS300 is equipped with a multiposition aluminium stand (with plastic handgrip at centre). However, a price is paid for the multiple positions of the handle in that the sides have to be pulled out to facilitate movement. This is not as easy as it sounds when the stand needs to be rotated by 90° or more, owing to the inflexible nature of the aluminium. Voltage selection can be made for a 100 V, 120 V, 220 V or 240 V line by 2 slider switches provided on the back panel, on which Z modulation and, unusually, ramp-out sockets as well as ground are provided.

The front panel is clearly laid out. All trigger functions are controlled by seven push-button switches, though the fact that two switches have to be latched simultaneously to enable Ext or TV triggering could be initially inconvenient. Alternate or chopped modes and TV line or frame triggering is automatically selected by the timebase switch, being dependent upon the sweep speed selected. Although bringing about a slight decrease in versatility when the scope is used in these modes, this arrangement is, however, justified by the resulting in-

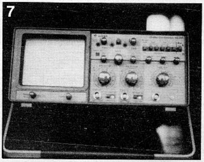


Fig. 7. Gould OS300 oscilloscope

crease in ease of use of the scope. Curiously, the on/off switch is combined with the intensity control, which is slightly inconvenient as the intensity control is reset during each on/off operation. Due to the quick heat cathode of the CRT, the intensity control can be set any time after the 10 seconds or so warm-up time of the CRT, which limits the inconvenience. The CRT bezel is not equipped with camera mounting facility, but Gould point out in the manual that this problem can be solved by holding a suitable camera against the tube face.

As can be seen from the specification, the maximum Y amplifier sensitivity is 2 mV/div, which is effective across the 20 MHz bandwidth (−3 dB). This extends upto 10 V/div calibrated or 25 V/div uncalibrated. The wide attenuation range allows a good range of input signals to be accurately measured. The good sensitivity permits a ×10 probe to be used with low voltage high impedance sources for the minimum minimum loading. On the whole, the Y amplifiers performed well, having a good response up their specified bandwidth and risetime but it was noticeable that the response did dip sharply after 25 MHz. As on most modern scopes in this price range, the input stage of the pre-preamplifiers is formed by FETs, here in a source follower configuration. The use of FETs obviously helps provide the high input impedance which is a vital quality of any oscilloscope. In common with those on some other oscilloscopes in this range, the Y amplifiers exhibit a small amount of drift (approximately ½ cm), during the 'warm-up' period thus making readjustment of the horizontal trace position necessary, after the initial 10 minutes of operation. An accuarate 1 V peak to peak (± 2%), 1 kHz square wave for ×10 probe calibration is provided.

The trigger performance of the OS300 is good, with triggering possible on a very large range of signals without major adjustment of the trigger threshold. Complex signal patterns are also handled without too many problems, although a digitized sine wave with its third MSB bit missing did require some fine adjustment of the triggering level to obtain a stable trace. High frequency triggering was also good with triggering on waveforms with frequencies very considerably higher then the 20 MHz Y amplifier bandwidth. The triggering selectors consist of a bank of 6 push-button switches, some of which have dual functions, e.g., two being depressed for one function. This leads to a slight decrease in flexibilty in some modes such as external triggering or TV sync, although it has to be said that this is minimal. Line or frame sync. is selected in the TV mode by the timebase switch and, although in theory this may appear again to be somewhat inflexible, in practice this is not so, as the automatic timebase selection is quicker and easier than manual switching. This also applies to chopped or alternate switching, which is also selected by the timebase speed. The chopping frequency is a notable 500 kHz, enabling relatively high frequency signals to be measured more accurately in this mode rather than in the alternate mode where, because of its nature, phase comparisons of waveforms can be inaccurate.

Sensitivity is good across the entire bandwidth ranging from about 1.5 mm at 2 MHz to 4 mm at 20 MHz. The OS300 still maintained a reasonable sensitivity at frequencies above 20 MHz. Alternate channel triggering of the timebase is not available and because of this, synchronization of the two input waveforms is necessary in dual trace mode in order to obtain a stable trace. Trigger coupling is also limited by the absence of low frequency or high frequency filters which are usually provided in scopes in this price range. Where these would normally be necessary, typically where the required trigger signal has a very high content of LF for an HF wave or HF for an LF wave modulation, the problem can usually be got around by critical adjustment of the triggering threshold. This is, however, not always the case and consequently necessitates the use of the external trigger facility.

The remaining trigger functions are fairly standard ones such as AC or DC coupling etc.
The timebase speed selection switch is to the right of the scope and has a total of 18 speeds ranging from 0.2 s/div to 0.5 μs/div. This can be expanded to 50 ns/div by a ×10 switch, making viewing of fast risetime waveforms easy.
My main criticism of the OS300 is its below average focusing, which is evident at most time base speeds, and results in a lack of sharpness and definition that some other scopes with 2 kV tubes possess. This is naturally most noticeable on the ×10 timebase speeds. The OS300's lack of automatic focusing does not help in the matter, so that a slight readjustment of the focusing control is necessary when changing over a wide range of timebase speeds. The brightness on the scope is admitedly very good for a 2 kV accelerating potential tube, but even at low intensity levels the trace still insists on appearing slightly defocused—both the focus and astigmatism controls level and certainly the brightness of the Mullard quick-heat-cathode CRT is very good. This quick heat cathode, as used in many modern TV's, enables the scope to become operational very much quicker (under 10 secs) than other instruments in its class (typically 30 secs).
The Gould OS300 is also fitted with Z modulation and, unusually, a ramp output. This output, although being only 3.5 V in amplitude (peak) can easily be amplified if necessary and used to drive such things as, for example, a VCO which in conjunction with a swept LO detector could be used to provide a spectrum analyser type display. This perhaps slightly ambitious application is one of many for which the ramp output can be used, as it ensures the synchronization of any external device with the scope thus producing a locked display. It is surprising that this helpful feature is not included in more scopes.
Internal construction is centred around a single large epoxy glass PCB which houses the vast majority of the circuitry, while a smaller vertical PCB contains the Y amplifiers and some timebase components. The Y amplifiers themselves are fully screened. Parts of these amplifiers are constructed from IC's which are housed in TO88 metal packages for further noise immunization. Overall internal construction is very neat: there are very few interconnecting wires, and, despite the fact that both PCBs are single-sided, also very few wire links. The PCBs and other large components such as the tube and the high-quality mains transformer are all mounted on a robust steel subframe onto which the sheet metal outer housing is fitted. A large part of the CRT is shrouded to guard against X-ray radiation etc. Most of the components used in the OS300 are

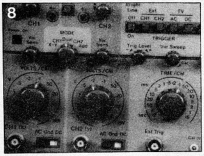


Fig. 8. Close-up of OS300 controls

of a high standard, but I have my doubts about the potentiometers used for some of the continuously variable front panel controls, which have a somewhat uneven movement, and upon inspection prove to be little more than presets. There is, however, no reason why these should prove to be unreliable. On the subject of presets, all are clearly labelled on the silk screened PCB and all are easily accessible. Components used in the scope come from a wide range of manufacturers ranging from National Semiconductor for some of the ICs to Magnetic Shields Ltd for the CRT shield.
The manual for the Gould is particularly good, totalling 26 pages plus the A3 size circuit diagrams. It covers the OS300 in some detail including sections on operation, maintenance and calibration. There is also a detailed circuit description so fault finding, etc., should present no problems. In addition, there are a large number of diagrams, both circuit and mechanical, which should be of help in many circumstances.

Conclusion

The Gould OS300 has its good and bad points. The good points include the excellent quality of construction, its ruggedness, the quick-heat cathode of the CRT, ease of operation, and the several time saving features. It is also worth bearing in mind that the instrument undergoes a large number of quality control procedures during and after construction such as the 36-hour soak test which is carried out on the completed instrument. While these are in no way unique to Gould, they do appear to be

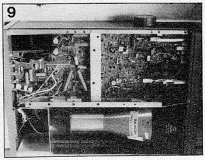


Fig. 9. Internal view of OS300

Table 5. Specification

ELECTRICAL CHARACTERISTICS
Designed for IEC 348 Cat. 1.
Line voltage: — 100,120,220,240 VAC ± 10%; externally adjustable. Power 50 Watts. Line frequency 45 . . . 440 Hz.

MECHANICAL CONSTRUCTION
Dimensions: — W 305 mm, H 140 mm, D 460 mm
Housing: — Sheet steel
Weight: — approx. 5.8 kg

Y AMPLIFIER ETC.
Coupling AC, Gnd or DC on both channels.
Operating modes: —
CH 1 alone
CH 2 alone or inverted
CH 2 + CH 1
Alternate or chopped (500 kHz)
CH 1/CH 2, switching automatic.
Frequency range (full deflection)
0 . . . 20 MHz (−3 dB) (DC coupled)
Risetime ≤ 17.5 nsec.
Deflection factor 12 steps;
2 mV/div . . . 10 V/div ± 3% (Min 25 V/div, fine control fully anti cw).
Input coupling AC, DC or Gnd.
Input impedance 1 MΩ/28 pF; Max input voltage 400 V DC or pk AC. Input protected.
Input impedance 1 MΩ/28 pF; Max input voltage 400 V DC or pk AC. Input protected.

X-Y MODE
CH 1 X-axis, CH 2 Y-axis. Bandwidth DC-1 MHz (−3 dB). Less than 3° phase shift at 50 kHz.

TIMEBASE
Deflection factor 18 steps;
0.5 μsec . . . 0.2 sec/div ± 3% in 1/2/5 sequence. Min speed 0.5 sec/div (fine control fully anti cw).
Expansion ×10, extends max. timebase speed to 50 nsec/div. Expansion error ≤ ± 2% extra.

TRIGGERING
Trigger modes: — Auto (bright line), Normal, TV (active line or frame sync. automatically selected from timebase speed.)
Trigger coupling: — AC, DC.
Trigger sources: — CH 1, CH 2, Ext.
Triggering slope: — positive or negative, switchable.
Trigger sensitivity: — Internal (DC) 5 mm to 20 MHz. External (DC) 400 mV to 20 MHz; All modes.

MISCELLANEOUS
CRT—make Mullard, measuring screen 100×80 mm, accelerating potential 2 kV, quick-heat cathode. Protective screen built into bezel.
Compensation signal for divider probe, amplitude approx. 1 V ± 2%; frequency 1 kHz.
Z modulation—input by 4 mm socket; 2 V visible mod. + 40 V complete blanking.
Ramp out . . . + 3.5 V peak from 5 kΩ.
Covered by 2 year warranty.

particularly stringent in this case, being backed up by the instrument's two year guarantee. As to the bad points, my main criticisms are the focusing of the CRT and the lack of alternate triggering. Summing up, the Gould OS300 oscilloscope is probably best suited to environments where its high grade of construction will be valued, such as educational establishments or servicing departments, and its few shortcomings will not be noticed.

The Gould OS300 was supplied by Gould Electronics Ltd., Instrument Systems, Roebuck Road, Hainault, Ilford Essex IG6 3UE. It retails at £342 + VAT.

No other oscilloscopes under £1,000 are manufactured by Gould.

Table 6.

CATEGORY	Unsatisfactory	Satisfactory	Good	Very Good	Excellent
TRIGGER FACILITIES			×		
TRIGGER PERFORMANCE				×	
CRT BRIGHTNESS				×	
CRT FOCUSING		×			
Y AMP PERFORMANCE				×	
INTERNAL CONSTRUCTION					×
EXTERNAL CONSTRUCTION				×	
OVERALL SPECIFICATION			×		
EASE OF USE				×	
MANUAL					×
X/Y PERFORMANCE				×	

Grundig MO20

The German company of Grundig has long been renowned for its high quality consumer products, and, perhaps not surprisingly, the Grundig MO20 largely keeps to this mould. The MO20 is one of 3 oscilloscopes manufactured by Grundig aimed at the 'under £1000 market': the others being the MO22 and the MO53. The MO20 is the cheapest in this range retailing at £365 + VAT. This price, in common with many other foreign products, has been adversly affected by the exchange rates: it was £66 pounds lower at £299 in August of 1986.

The Grundig MO20 arrived well packed in a cardboard box, substantially larger than the instrument itself, which was encased in a number of polystyrene cutouts. On removal, the Grundig turned out to be fitted with a two pin continental plug, which entails either using an adaptor or, more preferably, refitting with a 13 amp plug. The lead feeds straight into the scope and is not fitted with a socket. This is unfortunate because it is of only average length and in some situations a longer lead may be required. The stand is moulded in a tough plastic and is well up to supporting the heavier than average (8½ kg) MO20, but it has only one position. The front panel is clearly laid out, although the vertical mode switches are initially confusing. However, the method of using two switches for the vertical mode pays dividends when in the X-Y mode, which due to the design is extremely versatile. Upon inspection of the manual, it would be all too easy to describe the Grundig as a run-of-the-mill oscilloscope, with perhaps the notable feature in this price range of having automatic peak value triggering, but this is not the case. A summary of the specifications is provided in Table 7.

As can be seen, the maximum calibrated

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Fig. 10. The Grundig MO20 oscilloscope

Y amplifier sensitivity is 5 mV/cm although, unusually, the fine adjustment control calibrated to give a maximum gain of ×2.5 actually increases the sensitivity, resulting in a sensitivity of 2 mV. I found this to be accurately calibrated, although the system of using the fine control to increase sensitivity was at first off-putting as on most scopes it decreases sensitivity. The Y amps performed well handling an almost full height (6 cm) sine wave with little degradation in height over the full 20 MHz bandwidth of the instrument. When fed with a fast rise time pulse, the Y amps responded within the specified limit of 17.5 ns. It was pleasing to note that the range extends to 20 V/cm, which permits the measurement of relatively high voltages in the dual trace mode without any overlapping of traces,

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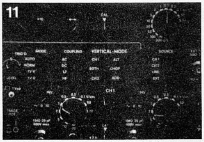

Fig. 11. Close-up of MO20 controls

while using a ×10 probe. Both channels are invertable, making for easier subtracting, as no swapping of connectors is required for changing the subtraction waveform. One minor but annoying point was that both Y amplifiers on the review model exhibited a small amount of drift (about ½ cm) over the fist 10 minutes of operation, necessitating an adjustment in their trace position. This does not, however, affect normal measurements outside the 'warm up' time during which I found both channels very stable. A 1 V peak-to-peak 1 kHz probe calibration waveform is provided having a rise time of 5 μs.

The MO20 boasts an automatic peak value trigger, which enables the scope to lock on to virtually any repetitive waveform of above 7 mm in amplitude, without adjustment of the triggering threshold. This has advantages in that alteration of the manual trigger value is not necessary for variations in waveform amplitude etc. thus making operation easier. Triggering on the MO20 is comprehensive: auto (peak triggering not bright line); normal, i.e. no bright line; or auto trigger and TV frame and line modes. On top of this, it also features AC, DC, LF ($f_g \simeq 8$ kHz) and HF ($f_G \simeq 10$ kHz) coupling. The source for these functions can be selected from either CH1, CH2, LINE or an external source. A notable exception here is that in common with most other oscilloscopes in this price range, alternate triggering from CH.1 and CH.2 is not available. This means that when both channels are being used both the input wavforms must be synchronized to a single source to enable both trces to be stable.

Selection of the trigger mode is by a number of lever operated switched. These are not only easy and convenient to operate, but also provide a clear indication of which function has been selected; they are also used for vertical mode selection. I found the triggering facilities of the Grundig very good, although a slightly more sensitive auto trigger function would have saved adjustment of the Y amps in a few cases. The scope triggered successfully on a large variety of waveforms ranging from NRZ pulses to a heavily modulated sine wave at 20 MHz. In some cases, it was necessary to switch into normal mode to obtain a fully stable trace, but this was relatively rare. The auto trigger function does however take a few tenths of a second to lock onto a signal, and during this time the display is blanked, producing a rather disconcerting flickering if the Y amplifiers range is changed or the trigger signal falls below the trigger threshold. Despite this, the auto trigger function performed very well, its usefulness extended by the inclusion of a LED indicator to show the trigger state of the scope.

Time base speed selection is by means of an 18-position switch and ranges from 0.2 sec/div to 0.5 μsec/div, a ×10 switch increasing this to 50 ns/div. A fine adjustment control is capable of slowing the trace down by a factor of up to 2½. The focusing and brightness of the VALVO CRT were very good even at maximum sweep speeds, although there was a small amount of defocusing when the ×10 control was brought into operation, the intensity control being suitably advanced to compensate for the loss in brightness. Defocusing was also observed when the intensity control was at maximum. These problems are really to be expected with a 2 kV tube as fitted to virtually every scope under £500. The maximum sweep speed (×10) proved to be fast enough for observing signals at the full 20 MHz bandwidth, the overshoot on a 10 MHz square wave being clearly visible. The CRT is clearly marked with the appropriate graduations for rise time measurement, which is made easy by the comprehensive triggering facilities. There is no filter in front of the CRT so that the colour of the CRT appears true: greyish white with a red graticule. Although Z modulation is not fitted as standard I was surprised to read in the manual that it can easily be fitted by the addition of one BNC socket connected to a clearly marked point on the PCB. The bright level is specified as ≤0.8 V and the dark level as ≥2.0 V.

Overall the construction of the Grundig MO20 appears to be excellent for an oscilloscope in its price range. The case is solidly constructed from relatively heavy gauge steel and, since the instrument only consumes 35 Watts of power, no ventilation slots are necessary. The front and rear surrounds are cast metal: most of the front panel is plastic, and the rear is of sheet steel. The use of steel does, of

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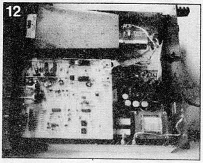


Fig. 12. Internal view of MO20

course, have its drawbacks in terms of weight over the more frequently used aluminium, but in my view the extra strenght obtained compensates for this. On removal of the top cover the internal layout was found to be very neat, with a minimum of interconnecting wires. The majority of the components are mounted on two fibreglass PCBs: one large board houses the power supplies, Y amplifiers, blanking circuit etc, and a smaller board houses the ramp generator, triggering filters etc. Both boards are single sided, the larger of the two having a large number of wire links. Connections between the boards are made by a thick form of ribbon cable. Both boards are silk screened, and are fitted with numerous test pins, all of which are clearly labelled as to their function and, where appropriate, expected voltage. The majority of the integrated circuits are manufactured by Texas Instruments, although several, including the input amplifiers, are from other manufacturers. The input amplifiers are soundly constructed and fully shrouded with sheet metal, as is the CRT. The attenuation range switches appear to be of a high quality construction, and have a positive action. One minor point is that both the attenuation switches and the timebase switch have no end stops, so that it is all too easy to accidentally switch from the maximum range to the minimum or vice versa. Personally, I didn't like this because of the reason outlined above, but this a purely personal view. The timebase switch, which is based around a small vertically mounted PCB, did not appear to be of such quite good quality as the attenuator switches, but was still acceptable. All other components appeared to be of a very high quality.

Servicing or calibration of the scope should be no problem, as most of the components are fairly standard, although there are several thick film resistor networks. The large number of marked test points greatly eases fault-finding and calibration. Unfortunately, the manual only gives a brief list of the internal presets and suitable calibration procedures. None the less, these are quite helpful and should be sufficient for most users requirements. The

Table 7. Specification

ELECTRICAL CHARACTERISTICS: —
Protection class 1.
Line voltage: — 110,220,240 VAC ± 10%; internally adjustable. Power 35 Watts. Line frequency 45 . . . 65 Hz.

MECHANICAL CONSTRUCTION
Dimensions: — W 375 mm, H 160 mm, D 430 mm
Housing: — sheet steel
Weight: — approx. 8.5 kg

Y AMPLIFIER ETC.
Operating modes: —
CH 1 alone or inverted
CH 2 alone or inverted
CH 1 + CH 2
alternate or chopped (250 kHz) CH 1/CH 2
Frequency range (6 cm deflection) 0 . . . 20 MHz (−3 dB).
Risetime ≤ 17.5 nsec.
Deflection factor 12 steps: 5 mV/div . . . 20 V/div ± 3% (Max. 2 mV; fine control full cw).
Input coupling AC, DC or Gnd.
Input impedance 1 MΩ/25 pF, Max input voltage 400 V (peak including DC voltage).

X-Y MODE
CH 1 X-axis, CH 2 Y-axis. Bandwidth DC-1 MHz (− 3 dB). Less than 3° phase shift at 50 kHz.

TIMEBASE
Deflection factor 0.5 μsec/div . . . 0.2 sec/div + 3% with 1/2/5 divisions.
Expansion × 10; extends max. timebase speed to 50 nsec/div; expansion error ≤ ± 2% extra.

TRIGGERING
Trigger modes: — Auto with peak value triggering from f>10 Hz; Normal; Active TV frame and line sync.
Trigger coupling: — AC, DC, LF ($f_g \simeq 8$ kHz), HF ($f_g \simeq 10$ kHz).

Trigger sources: — CH 1, CH 2, Line, Ext.
Triggering slope: — positive or negative, switchable.
Triggering sensitivity: — Internal ≤1 cm at 20 MHz, External ≤500 mV at 20 MHz, Normal mode.
Trigger signal indicator: — green LED.

MISCELLANEOUS
CRT-make VALVO, measuring screen 100 × 80 mm; accelerating voltage 2 kV; beam rotation by front panel adjustment.
Compensation signal for divider probe, amplitude aprox. 1 V_{pp}, frequency 1 kHz.
Z modulation-possible by addition of BNC socket, bright level ≤0.8 V, dark level ≥2.0 V.
Covered by 1 year warranty.

manual itself is quite good, covering a total of 16 pages (plus block and circuit diagrams), of which 8 pages is in German, the remainder being the English translation. Overall, the A4 size manual provided a good, if short, summary of the functions, set-up procedures, and applications of the MO20. In addition, details on fitting the Z-modulation socket, test characteristics and detailed specifications were also included. The circuit diagrams themselves are very clearly laid out and easy to follow, as is the block diagram. These are provided on fairly large pieces of paper which makes reference easy.

Table 8.

CATEGORY	Unsatis-factory	Satis-factory	Good	Very Good	Excellent
TRIGGER FACILITIES				×	
TRIGGER PERFORMANCE					×
CRT BRIGHTNESS				×	
CRT FOCUSING				×	
Y AMP PERFORMANCE			×		
INTERNAL CONSTRUCTION				×	
EXTERNAL CONSTRUCTION					×
OVERALL SPECIFICATION				×	
EASE OF USE		×			
MANUAL			×		
X/Y PERFORMANCE					×

Conclusion

The Grundig MO20 is certainly worth considering, its particular strengths lying in its construction and advanced triggering facilities. The construction is very good for an oscilloscope in this price range and the two-year guarantee offered with the scope reinforces this. The triggering facilities are good, with the particular bonus of automatic peak value triggering, as well as comprehensive filtering. It is a pity, however, that alternate triggering is not available. The CRT and drive circuitry are also very good, producing a clear and bright trace, even at the maximum deflection speed. To sum up, the Grundig MO20 is certainly worth buying if you require a well-built oscilloscope with a good range of facilities.

The Grundig MO20 oscilloscope was supplied by Electronic Brokers and retails at £365 plus VAT. Electronic Brokers are at 140-146 Camden Street, London NW1 0PB; telephone 01-267 7070.

Other Grundig scopes under £1000

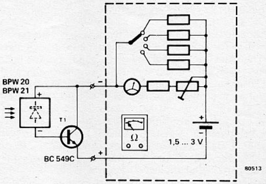
MO22—As the MO20 plus automatic timebase selection, triggerable second timebase, hold off control, Z mod. Current price £499 + VAT.

MO53—As the MO22 plus alternating second timebase, digital timebase display, 50 MHz bandwidth, delay time multiplier. Current price £750 + VAT.

cheap light meter

When developing photographs a light meter can be a useful gadget. Of course, the more luxurious the better, but as the diagram here shows, a simple circuit can also be very effective. The circuit is constructed around a photodiode. In a camera the diode generates enough voltage to control a meter directly. Often, however, there is not enough light under the enlarger. That is why a transistor has been added. Unfortunately, this also puts an end to the original design's simplicity, for now a battery will also be necessary. One solution is to connect the light meter to an ordinary multimeter switched to the resistance range. This is indicated inside the dotted line. Remember that the positive test lead of most meters is the negative pole for the resistance range!

Operation is as follows. The test diode is connected between the collector and base of the transistor. The more light that falls on the diode, the more the latter will conduct, thus providing the transistor with more base drive current. The collector current then increases (almost) linearly and this is indicated on the meter's dial.



Telecom 87: a preliminary report

Telecom is the quadrennial communications exposition organized by the International Telecommunication Union (ITU). It is the world's largest, most authoritative and comprehensive telecommunications event, attracting exhibitors and visitors from all over the world. In the 4 years since Telecom 83, great strides have been made by the telecommunication industry. This could not have been reflected better than by the main theme of Telecom 87: *"The Communications age: networks and services for a world of nations"*. The ITU, as part of the United Nations, has a co-ordinating, advisory and regulating function as regards worldwide telecommunication. But *"a world of nations"* is indicative of incompatibility, or, quite literally, *a world* of difference, between nations' standards and preferences for expanding existing telecommunications networks. In spite of the modern means available for global communication, technology in each of the ITU's 162 member countries is developing at its own pace, often dictated by political and economical factors. The ITU organizes Telecom to enable national PTTs and telecommunication companies from all over the world to see the latest technical achievements. This, hopefully, leads to discussions on the ways in which these can be integrated into existing telecommunication structures. Again, there is the risk of incompatibility between existing and new systems, and this is exactly what the ITU strives to eradicate or prevent with the aid of a comprehensive exposition. In this respect, it is interesting to quote the Secretary General of the ITU, R. E. Butler: *"The successive Telecom exhibitions owe their success to the fact that the ITU was in a position to offer, within a neutral framework immune to external influence, facilities for meeting and interchange which were soon recognized as a valuable service rendered to our member countries as well as to the operating organizations and the telecommunications industry."*

Telecom 87 was held in Geneva, the headquarters of the ITU, from 19 to 27 October 1987. The venue was the Palais des Expositions (Palexpo), which is within walking distance of the Geneva airport. The total number of exhibitors was close to 900, and some 50,000 visitors were received representing 200,000 entries. The total net exhibition surface was 53,500 m^2 inside, and 9,000 m^2 outside Palexpo. These figures mark the growth and importance of the telecommunications industry when compared to the net surface of 10,000 m^2 used for the first Telecom exhibition in 1971. Asociated events during Telecom 87 were:

- 5 Forums, in which press representatives, experts and officials, and other Telecom 87 attendants from the ITU member countries were given a chance to discuss openly various themes related to telecommunication;
- the 3rd Book and Audiovisual Fair on telecommunication, electronics and associated disciplines;
- the 5th International Film Festival culminating in the award of the"Golden Antenna";
- the 5th Youth in the Electronic Age competition.

The first day, 19 October, was certainly the most interesting for the numerous press representatives, since Telecom was not yet opened for the general public. Although it was announced that accredited press members would have a unique opportunity of arranging meetings and interviews with VIPs and ITU officials, the day (and much of the evening) saw installation personnel and many engineers working frantically to get their company's booth, display, or stand ready in time. All this business offered a unique chance to study brand new equipment and connection techniques from close by before it was carefully tucked away behind attractive looking panels with letters and lighting in various colours. Painting, opening crates, carpet laying as well as connecting terminals to mainframes and digital exhanges was carried out as "last minute" work. Outside the Palexpo building, on a specially reserved site, 30 or so dish aerials of widely varying size were being brought into service to enable permanent and "live" demonstations of satellite communication for the coming exhibition days. The signals to and from the transportable dish stations were carried to the various stands via cables, or short-range microwave links via the roof of the Palexpo building.

Telecom is not an exposition where one has to press through masses of visitors to get a glimpse of the material on display. The various commercial and technical representatives of exhibiting companies were eager to demonstrate new equipment to any interested visitor, although some of the questions asked were so deeply involved with technical details as to require noting separately and forwarding to an expert colleague in the relevant department "at home". Press releases were not scarce either, making it very difficult, if not impossible, to leave Palexpo without bags of documentation and souvenirs for the occasion. The press room was hectic, and cluttered with paper. A number of companies used the press notice board to criticize competitors' products by means of hurriedly issued information bulletins. Cocktails, lunches and important speeches were scheduled and again postponed for maximum impact on the press representatives.

The main theme of Telecom 87 was excellently reflected by the Hall of Nations, in which individual countries had set up "national pavilions" accommodating the stands of many smaller, and often highly specialized, companies. The Italian, French, Northern American, Scandinavian and West German pavilions were remarkable for the impressive number of companies accommodated. Many companies were present with their corporate stand, and in addition as part of a national pavilion. Examples were Siemens, Motorola and Philips/AT&T.

Companies and institutions with related products and services were located close to one another in the halls. Inmarsat's "Great Maritime & Land Mobile Show", and the 1:4 scaled model of Ariane 4 were successful eye-catchers calling visitors in the direction of a number of important representatives in the communications satellite field: EuroSatellite, ESA, Inmarsat, Hughes Aircraft, Intelsat, ArianeSpace, General Dynamics and EutelSat.

Telecom 87 focused heavily on integrated digital networks (ISDN) and satellite communications. NTT (Nippon Telephone & Telegraph Company), Matsushita, NEC, GEC/Plessey and AT&T/Philips attracted many visitors with live demonstrations of ISDN. In an ISDN system, telephone calls, telex, facsimile, slow-scan images, and LAN-like digital services are all "packed together" for high-speed transmission via fibre optic links or geosynchronous communication satellites. System X from GEC/Plessey is generally expected to govern the new technical outlook of all-digital, and ISDN compatible, data exchange systems. In fact, System X equipment has been in use for a number of years in all British Telecom trunk exchanges, but the latest enhancements to the system as regards the transmission speed achievable over satellite links has aroused the interest of many national PTTs looking for ways to extend existing telephone networks. ISDN and satellite communication are closely related, and the relevant products and services of many leading telecommunication companies will be discussed in next month's issue of *Elektor Electronics*.

STEREO LIMITER

A quality limiter for use in tape recorders, transmitters, public address systems, and discotheques.

A limiter is an electronic volume adjustment circuit in which AF signals are amplified up to a predefined level of the input amplitude. When this level is reached, the gain of the amplifier is reduced to ensure that a fixed, maximum, output level is not exceeded. In other words, the output amplitude remains constant irrespective of fluctuations of the input signal above the limiting threshold. Limiting is, therefore, often referred to as *dynamic range compression*. Figure 1 shows the dynamic response—U_o as a function of U_i—of the proposed limiter.

The design described here is based on a pair of standard gain controlled amplifiers which ensure a dynamic range compression of about 46 dB. The limiting threshold is reached at an input voltage of about 50 mV: the output voltage is then about 670 mV.

Circuit description

With reference to the circuit diagram of the stereo limiter in Fig. 2, opamp A_1 sums the signals applied to the L and R inputs, and provides the gain control signal for the limiter chip Type NE572 in position IC_3. Although it is economical to provide a gain control signal common to both channels, the result is, of course, the likelihood of mutual and inappropriate gain reduction on the stereo outputs. Fortunately, this effect does not raise problems for programme material played at average to loud levels, and the differences in output volume on the channels are certainly tolerable at less than 5 dB.

Both channels in the Type NE572 dual programmable analogue compander (compressor-expander) from Valvo/Mullard comprise a full-wave *rectifier*, a *buffer* and a linearized, temperature compensated *gain cell*. All these operate independently from the corresponding section in the other channel. The rectifier translates the AF signal from A_1 into a direct control current for the buffer, which in turn controls the output current provided by the associated gain cell, marked ΔG in the circuit diagram. The attack and recovery constants of the gain controlled buffers are determined with the aid of external electrolytic capacitors C_5-C_6 (L) and C_{12}-C_{13} (R). The outputs of the current controlled gain cells ΔG are connected to the feedback resistors of opamps A_5 (L; R_5) and A_6 (R; R_{12}). Hence, the output current provided by the gain cells controls the attenuation introduced by A_5 and A_6. In the present application, the operation of the gain cells is, therefore, comparable to that of a current controlled electronic potentiometer. Output opamps A_2 (L) and A_4 (R) are dimensioned for an amplification of about 4.7. The oscillograms of Fig. 3 show the dynamic response of the limiter.

It is evident that the technical characteristics of the proposed limiter are a compromise between what is useful on the one hand, and practical for most applications on the other. This means that the input threshold, the output level, the dynamic range and the tracking(gain dis-

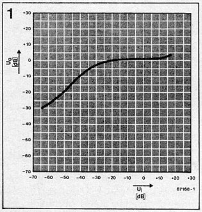


Fig. 1. Dynamic response of the stereo limiter.

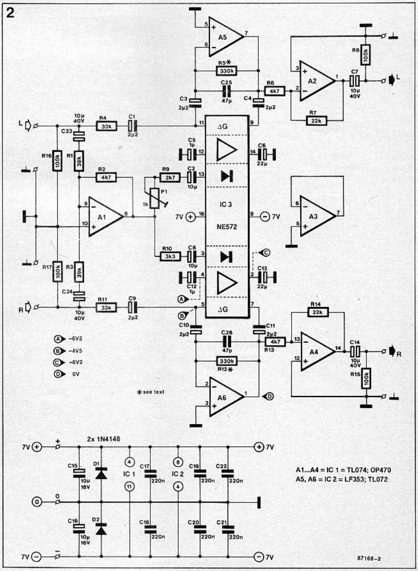


Fig. 2. Circuit diagram of the stereo limiter.

tribution) of the channels are dimensioned such that the circuit is suitable for a wide variety of applications. In some cases, the technical characteristics may need altering, however.
Resistor R_5 (R_{12}) sets the maximum amplification for an optimum signal to noise ratio in the absence of an input signal. The maximum usable resistance is about 680K. The gain cells operate at a bias potential of about −5 V, while the + input of the associated operational amplifier (pin 5; 3) is connected to ground. This means that the maximum drive for A_5 (A_6) is about 1.4 V_{rms}. Both gain controlled opamps function as an alternating voltage amplifier, and do not, therefore, need a coupling capacitor to the associated output driver.
The attack constant is determined with C_{12}; C_5 (R; L), the release constant with C_{13}; C_6 (R; L).
The main point in the dimensioning of the control circuit concerns the selection of the control voltage for the gain cells. In practice, it was found that the drive margin can not be set much higher than −25 dB, corresponding to the already stated 50 mV (0 dB≙1 mW in 600 Ω).
The input voltage should, therefore, not exceed 130 mV_{rms} to avoid overdriving the limiter, since this would then operate linearly again, amplifying the input signal. To avoid any risk of this happening, it is recommended to fit presets with a value of, say, 100 kΩ at both limiter inputs.
The tracking (gain balance) of the channels is optimized with the aid of P_1. The correct adjustment is reached after checking, noting and comparing the dynamic response curves of the L and R channel with the aid of a calibrated sine-wave generator, an oscilloscope and a true-rms meter.
In the absence of these instruments, acceptable results are obtained when P_1 is set to the centre of its travel.

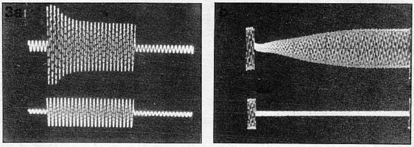


Fig. 3. Automatic level control obtained with the limiter. Small signal response (b) and large signal response (a). Upper channel: output; lower channel: input.

Construction and use

The ready-made printed circuit board for the stereo limiter is shown in Fig. 4.
Construction follows the usual pattern of fitting the components as per the parts list and the white overlay on the PCB. Fit the ICs in sockets, and do not forget the 2 short wire links between C_{20} and C_{21}. The capacitors in the corners of the PCB are bipolar (*non-polarized*) types.

Attention: pin 5 of IC_2 is erroneously left unconnected on the PCB. This is readily amended by running a short length of light insulated wire from pin 5 to the ground connection of C_{20}.

The supply voltages for the limiter can be obtained by stepping down ±10, ±12 or ±15 V rails available in the equipment to incorporate the stereo limiter.

Parts list

Resistors (±5%):
R_1;R_3 = 39K
R_2 = 4K7
R_4;R_{11} = 33K
R_5;R_{12} = 330K
R_6;R_{13} = 4K7
R_7;R_{14} = 22K
R_8;R_{15};R_{16};R_{17} = 100K
R_9 = 2K7
R_{10} = 3K3
P_1 = 1K0 preset H

Capacitors:
C_1;C_3;C_4;C_9;C_{10};C_{11} = 2μ2; 25 V
C_2;C_8;C_{15};C_{16} = 10μ; 16 V
C_5;C_{12} = 1μ; 25 V
C_6;C_{13} = 22μ; 25 V
C_7;C_{14};C_{23};C_{24} = 10μ; 40 V; bipolar⁺
C_{17} . . . C_{22} incl. = 220n
C_{25};C_{26} = 47p

⁺ e.g. Maplin order no. FB06G, or Cirkit stock no. 04-10613

Semiconductors:
D_1;D_2 = 1N4148
IC_1 = TL074 or OP-470
IC_2 = LF353 or TL072
IC_3 = NE572* (Valvo/Philips/Mullard)

* Available from Universal Semiconductor Devices Limited.

Miscellaneous:
PCB Type 87168 (see Readers Services page)

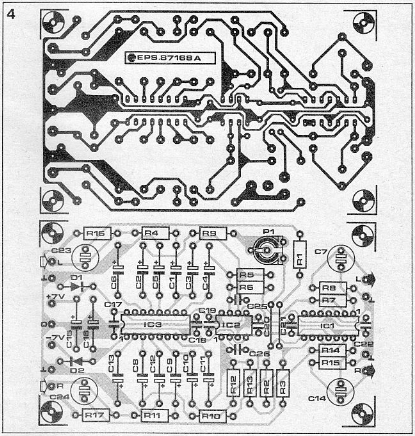
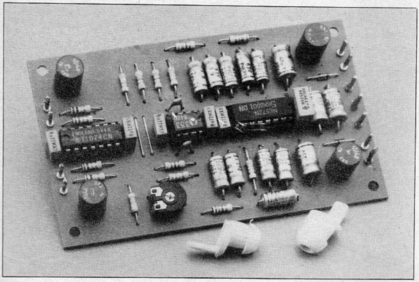


Fig. 4. Track layout and component mounting plan for the printed circuit board. PLEASE REFER TO THE TEXT FOR THE CONNECTION OF IC_2, PIN 5.



Zener diodes and discrete regulators are equally suitable for providing the regulated ±7 V supply voltage.
The limiter is best connected permanently between the outputs of a line driver or mixer, and the inputs of the power amplifier. After establishing the drive margin of the system, the output and input level presets (if used) are sealed to avoid overdriving the power amplifier and the limiter, respectively.*Gb*

SCIENCE MOBILISES TO BEAT MURDER IN THE AIR

by Bill Pressdee, BSc, CEng, MIEE

The problems confronting airport security are basically the same as those involved in the custody of any major industrial complex of national importance. These include theft, ranging from petty larcency to bullion robbery, illicit incursion, ranging from unauthorized entry to military takeover, and specifically terrorist attack, either in the airport or in the air.
Combatting these problems calls for adequate surveillance by man or machine to discover illegal acts, and the appropriate detection of illicit devices or materials in sufficient time to apply remedial action.
Incidents at airports—such as bullion robbery, the smuggling of drugs, or the discovery of explosives in hand luggage—are generally reported in isolation. However, to be effective, an airport system must be comprehensive to cover every aspect of security. For each airport, the security system must first take account of the particular site problems.
There are many security devices available for use around the airfield, and these should be deployed to monitor various zones of increasing risk, starting at the perimeter fence: microphonic cable to detect break in; closed circuit television (CCTV) cameras to scan various sectors of the airfield (possibly connected to motion detectors); and infrared, microwave and underground pressure detectors to discover intruders and vehicles in unauthorized areas.

Searching the public

Chubb Alarms is a major British security company marketing a comprehensive range of such devices, and has considerable expertise to advise how an area can best be protected.
Of more critical concern at present, however, are the airport areas to which the public have access—in particular the interfaces between the public areas and those restricted to passengers and airport staff. Through these pass the passengers, their baggage and their hand luggage, each piece of which may be concealing weapons or explosives, or the means for making or assembling them.

Luggage inspected for explosives using the A.I. Security Type 97.

It is at these interfaces that, as the criminal and would-be terrorist become more ingenious, the detectors deployed against them need to become more effective.
CCTV is an important general means of monitoring the concourse of the airport and noting irregularities. The recent development of charge coupled device (CCD) cameras using solid state image sensors is a major step towards improved CCTV surveillance. The units are extremely small, allowing covert operation; they have a long life, are robust, need negligible maintenance and work at low voltage with power consumption of just a few watts.

Finding metal

Coupled via a fibre optic taper to a microchannel plate image intensifier, they are capable of operation over all ranges of ambient illumination from bright sunlight to starlight. The English Electric Valve Company Ltd has recently announced a comprehensive range of CCD cameras and sensors manufactured in its new factory at Chelmsford, eastern

England, the most advanced CCD facility in Europe.

Firearms and most other weapons will incorporate a substantial amount of metal, which may be detected by X-ray machines or metal detectors. Passengers, on entering the airport's departure area, and possibly also before embarking, may be required to pass through an archway incorporating a metal detector (and perhaps including an explosives detector as well, as in the A.I. Security Entry Scan Type 85).

The threshold sensitivity of the detector will be set to discriminate between, say, a small pistol and loose coins in the passengers' pockets: warnings of significant metal detection may then prompt further investigations by means of a physical body search or hand held metal detector such as the GM2 made by Graseby Dynamics.

Baggage and hand luggage is normally inspected via an X-ray machine, tended by an operator trained to identify suspicious opaque profiles. Recent products from Astrophysics Research, which has supplied over 2000 such machines worldwide, include a combined check-in desk and X-ray screening system and mobile systems for spot checks.

Explosives threat

Detection of illegal objects depends at present on the operator's alertness and experience, but the advent of microprocessors operating at several million instructions per second heralds the development of expert detection systems in which the X-ray responses will be compared automatically with a multitude of those from known weapon types.

Explosives represent the most deadly of the armaments available to the terrorist and also, even when made into improvised bombs, the most difficult to detect. The minimal amount of metal in the detonator or triggering device is unlikely to reach the alarm thresholds for archway or hand held metal detectors.

Accordingly, over the last two decades several types of explosive detector have been developed. Explosive compounds, their additives and decomposition products emit minute quantities of a characteristic vapour, which is possible to sample and identify—although with some modern military explosives this is far from easy.

The simplest sniffer devices available rely on direct ionization of the vapour from the explosives in air. These include typically the Graseby Dynamics PD4C and the A.I. Security Model 35, which are light, compact and easy to use. Although they perform a useful function, their sensitivity is limited, their discrimination medial, and they are unlikely to respond to certain military explosives.

Finer sampling

A more sensitive and selective range of instruments is available, based on gas chromatography. It includes the A.I. Security Model 97. These devices rely on a constant and very pure supply of inert gas, and the means for introduction of the atmospheric sample into the gas stream. The penalties for increased sophistication, however, appear in terms of increased size, weight, warm-up time, response time, and cost.

The only other detectors in being are the very complex and accurate instruments mostly confined by their size and lack of portability to laboratories, except for a recent product of Graseby Dynamics, the Ion Mobility Spectroscope (IMS), Model PD5 which shows considerable promise.

The IMS operates by first drawing an air sample through a probe and over a membrane, which excludes dust and moisture, but permits the diffusion of the vapour molecules. The molecules are then ionized by a weak Nickel-63 beta emitter and subjected to a 1000 V DC field, controlled by a gating grid which allows the passage of the ions in discrete samples. The drifting ions become ranged spatially in order of their mobilities, and, on reaching the collector electrode, present a current waveform characteristic of the ions in the sample. The internal air stream is circulated by a pump and dried. Then certain dopant chemicals are added in minute quantities to enhance the sensitivity.

The waveform received by the collector is digitized and fed to a microprocessor, in which its characteristics are assessed against patterns for various explosives, while vapours derived from other substances are disregarded. The PD5 has a hand-held unit with digital readout connected by an umbilical to a briefcase, making it ideally portable.

In many aspects the means for ensuring good airport security are becoming better and more sophisticated. It remains only for airport authorities to develop security systems that use these means effectively.

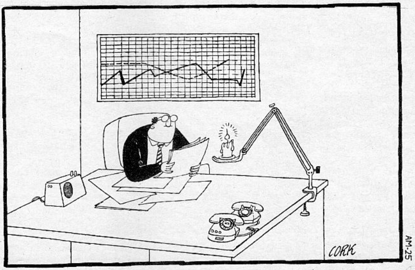
A.I. Security (Division of Analytical Instruments Ltd), Pampisford, Cambridge CB2 4EF.

Graseby Dynamics Ltd, 459 Park Avenue, Bushey, Watford WD2 2BW.

EEV Solid State Devices, (English Electric Valve Company Ltd), Waterhouse Lane, Chelmsford, Essex CM1 2QU.

Chubb Alarms Ltd, 42-50 Hersham Road, Walton-on-Thames, Surrey KT12 1RY.

Astrophysics Research Ltd, 100 Vale Road, Windsor, Berkshire SL4 5JP.



LIGHT POWERED THERMOMETER

An accurate, automatically operating electronic thermometer that indicates temperature on a digital readout without the need for batteries or a mains supply.

The thermometer described here is powered by an amorphous solar cell. In contrast to other types of solar cell, this uses a non-crystalline silicon layer. Amorphous solar cells are produced by controlled deposition of silicon on a glass surface, which forms the top of the cell. The production method is relatively simple and cost-effective, but has the disadvantage of yielding cells with a relatively low efficiency. The basic structure of an amorphous solar cell is shown in the diagram of Fig. 1. The element is composed of 3 series connected cells secured on a glass plate. Each photon that enters a cell causes the release of an electron from a silicon atom. The release generates electric energy, which can be used for powering the thermometer circuit—provided, of course, there is sufficient incident light on the solar cell.

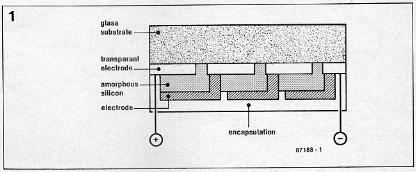


Fig. 1. Basic structure of an amorphous solar cell.

Circuit description

With reference to the circuit diagram of Fig. 2, the temperature sensor is formed by IC_2. This is the well-known precision centigrade temperature sensor Type LM35CZ from National Semiconductor. Housed in a plastic TO92 enclosure, this device gives a linear output voltage of +10.0 mV/°C. It does not require any external calibration or trimming, and yet provides an accuracy of ±0.25 °C at room temperature, and ±0.75 °C over the full −40 to +110 °C temperature range. The IC is internally calibrated such that 0 °C corresponds to an output voltage of 0 V. The remaining functions of the thermometer circuit are a voltmeter, a read-out, and a decimal point shifter. All these are combined in a single integrated circuit Type ICL7136 (IC_1), and a 3½ digit liquid crystal display (LCD). The oscillator internal to IC_1 is operated at the lowest possible clock speed to ensure minimum power consumption of the circuit whilst avoiding display flicker. The thermometer readout is calibrated with the aid of P_1. Components D_1 and R_{11} enable the sensor to provide a negative output potential when the temperature falls below 0 °C. LEDs D_1 and D_2 do not function as light sources, but as reasonably stable 1.6 V references that require a forward current of only a few micro-amps. Standard zener diodes give better regulation, but are not suitable here in view of the relatively high forward current required for the stabilization effect.

The circuit around IC_3 is a voltage

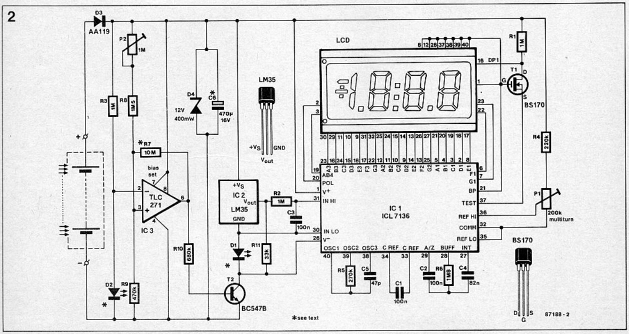


Fig. 2. Circuit diagram of the light powered thermometer.

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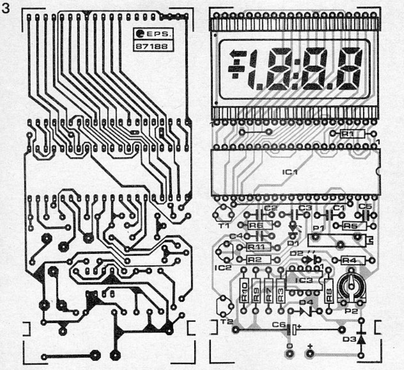

Fig. 3. Track layout and component mounting plan. The completed printed circuit board can be fitted in a transparent Heddic enclosure.

monitor that switches the thermometer off via T_2 when the potential supplied by the solar cell falls below 7.0 V. This protective measure effectively prevents erroneous read-outs: for accurate operation sensor IC_2 requires a minimum supply voltage of 5.5 V, while the reference source internal to IC_1 should be fed with 7.0 V or more. Schmitt-trigger IC_3 in the voltage monitor switches T_2 on again at an input voltage of 8 V, i.e., the circuit is dimensioned for a hysteresis of 1 V. The switch-on threshold is set at 7.0 V with the aid of preset P_2. The current consumption of the thermometer in the de-activated and activated state is about 10 and 200 μA, respectively. When the circuit is in the de-activated state, and there is moderate incident light, the solar cell can only supply about 100 μA, so that C_6 is charged to 8 V. The thermometer is switched on, and draws more current than can be supplied by the solar cell. This means that C_6 is discharged: the supply voltage drops below 7.0 V, and the thermometer is switched off again after a few seconds. This automatic on-off arrangement enables taking temperature readings even in less favourable weather conditions. The hysteresis of IC_3 can be increased by reducing the value of R_7, and re-adjusting P_2. It is possible to use a smaller capacitor for C_6, so that the thermometer is switched on rapidly when the light intensity increases. Finally, the function of D_7 is to limit the supply voltage to 12 V when there is intense sunlight on the solar cell.

Construction and setting up

The printed circuit board for the light powered thermometer is shown in Fig. 3. The completion of the board should not present difficulty, but care should be taken handling and mounting the fragile LC display. Do not overlook the 2 wire links on the board.

Do not yet fit IC_2, and apply +1.000 V to the points intended for the V_{out} and GND terminals of the sensor. Adjust P_1 for a display reading of 100 °C. Remove the voltage source connections, and fit IC_2. The completed PCB and the solar cell are made to fit in a transparent Heddic enclosure. The space is quite tight, and the drop of sealing resin on the LCD may have to be flattened by careful filing. One side of the enclosure of IC_1 is treated likewise. Use wire-wrap terminal strips so that the face of the LCD is pressed against the inside of the lid. Drill a few holes in the enclosure to prevent heat building up inside. The response of the sensor to rapid temperature changes can be improved somewhat by glueing a small piece of thin metal sheet onto the flat side of the TO92 enclosure.

Some spare room is available in the enclosure for an optional 9 V (PP3) battery. A switch can be fitted to select between the battery or the solar cell as the power supply for the thermometer. *TW*

Parts list

Resistors (±5%):
R_1;R_2;R_3 = 1M0
R_4 = 220K
R_5 = 270K
R_6 = 1M8
R_7 = 10M
R_8 = 1M5
R_9 = 470K
R_{10} = 680K
R_{11} = 33K
P_1 = 200K or 220K multiturn preset
P_2 = 1M0 preset H

Capacitors:
C_1;C_2;C_3 = 100n
C_4 = 82n
C_5 = 47p
C_6 = 470μ; 16 V

Semiconductors:
D_1;D_2 = LED; 3 mm; red
D_3 = AA119
D_4 = zenerdiode 12 V; 0.4 W
T_1 = BS170 +
T_2 = BC547B
IC_1 = ICL7136CPL ++
IC_2 = LM35CZ (Maplin order no. UF51F)
IC_3 = TLC271 +

+ available from Cricklewood Electronics Limited.
++ available from Universal Semiconductor Devices Limited.

Miscellaneous:
LCD = the following types may be used:
LTD221-C01 (Mullard/Videlec; for distributors refer to InfoCard 507 in the April 1987 issue of *EE*);
43D5R03 (Data Modul/LXD; 2D Electronics • Wellington House • 2 Kentwood Hill • Reading. Tel. (0734) 420440);
3901 or 3902 (Hamlin; Hamlin Electronic Europe Limited • Park Road • Diss • Norfolk IP22 3AY).
Solar Cell = U_o8 – 12 V, size: 48×96 mm. e.g. Solems Type JO887JB01*
Enclosure Heddic Type 222-G*.
PCB Type 87188 (refer to the Readers Services page).
PP3 battery (optional).
* Heiland Electronic Design & Development • Hermann Loens Strasse 11 • D-4410 Warendorf 3 • West Germany. Telephone: +49 (2582) 7550.
Availability in the UK: Chartland Electronics Limited • Chartland House • Twinoaks • Cobham • Surrey KT11 2QW. Telephone: (037 284) 2553.
For further details on distribution: Barnes Newman International Limited • Office Suite 1 • The Square, Forest Row • East Sussex RH18 5ES. Telephone: (034 282) 2708. Telex: 95637.

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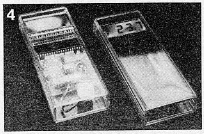
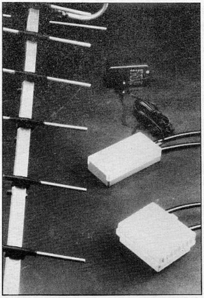


Fig. 4. Prototypes of the light powered thermometer.

WIDEBAND AERIAL BOOSTER AND SPLITTER

A single transistor amplifier and a matched RF signal distributor ensure that the signal provided by the aerial or cable network can be fed to several radio or TV sets without loss of quality.

Many people buy a second TV set for use in a location other than the living room. After experiencing the disappointing reception obtained by the use of the built-in or set-top aerial, it is often decided to connect the new TV to the same antenna input as the main set. However, the assumption that the signal strength is high enough to feed 2 TV sets is immediately proved false by ghost effects and considerably increased noise on. . . both sets!



Aerials and coax

A good quality directional aerial is the best RF amplifier. It is often frequency selective, consumes no power, introduces no noise, and gives considerable amplification. A typical multi-element Yagi aerial for UHF TV reception has a half power opening angle of about 15°, and a power gain of 12 to 16 dBi. Since the aerial is usually mounted in the highest possible location on the roof, its output signal needs to be fed down to the receiver via a cable that ensures minimum signal loss, freedom of induced interference, and correct matching at both ends. The loss introduced by a cable of any type (coax, twin-feed) is directly related to its length, and the frequency of the signal it carries. For coax, the loss is generally lower with increasing cable diameter. At 100 MHz, for instance, Type RG213/U cable has an attenuation of about 5.7 dB per 100 m, while RG58/U is specified at 14 dB. RG213/U ($Z_0 = 50\ \Omega$) and RG58/U ($Z_0 = 53.5\ \Omega$) have an outside diameter of 10.3 and 5 mm, respectively. The commonly used, general purpose, white coax for use in the home is certainly not better than RG58/U.

Although it is assumed here that constructors are familiar with the general rule that an RF amplifier should be fitted as close as possible to the aerial, the following example may prove helpful to illustrate the practical consequences if this is not the case.

Any electronic amplifier produces noise. Assuming that the circuit in question receives an input signal of 10 μV, and amplifies this, say, 10 times while adding 1 μV noise, it is readily seen that its output signal is composed of 100 μV "signal" and 1 μV noise, i.e., the signal to noise (S/N) ratio is 100:1. When the downlead coax has an attenuation of 4, the TV set receives 25 μV "signal" and 0.25 μV noise. Thus, the S/N ratio is not affected by the coax cable.

When the aerial amplifier is fitted at the low end of the downlead coax, i.e., close to the TV set, it receives a signal of 2.5 μV, which it amplifies to 25 μV. The noise level at the output is, again, 1 μV, however, so that the resultant S/N ratio is only 25:1. The signal amplitude is still 25 μV, but the noise level is quadrupled from 0.25 μV to 1 μV. The conclusion is obvious: the amplifier should be fitted as close as possible to the aerial, and the connection between them should be made in high quality (low loss) cable. In general, the amplification of the aerial booster ensures that the available S/N ratio is not affected by the downlead cable, even if this has considerable attenuation.

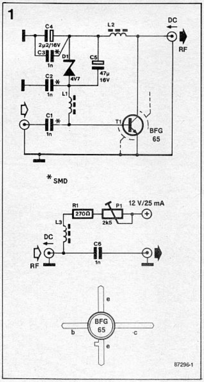


Fig. 1. Circuit diagram of the wideband aerial booster.

Wideband aerial booster

The amplifier described here is a wideband design with a frequency range of about 80—800 MHz. Its advantages are mainly the ease of construction, and the absence of tuned circuits. Its inherent disadvantages, are, however, equally important to note. The absence of any form of selective filters in the circuit may give rise to cross-modulation and blocking in the vicinity of powerful transmitters (mobile radios, TV transmitters, cellular radio repeaters, etc.).

With reference to the circuit diagram of Fig. 1, the amplifier is based on low noise RF transistor Type BFG65 from Mullard. Components P_1-R_1-L_3-C_6 are fitted close to a mains adaptor that provides a regulated output of 12 V. The amplifier is fed via the core of the downlead coax cable. Choke L_3 prevents the RF signals being short-circuited in the supply, while C_6 keeps the amplifier's supply voltage away from the TV input. The RF signal provided by T_1 is, therefore, superimposed on the supply voltage.

Zenerdiode D_1 keeps the base of T_1 at 4.7 V below the collector potential. Inductors L_1 and L_2 prevent RF feedback

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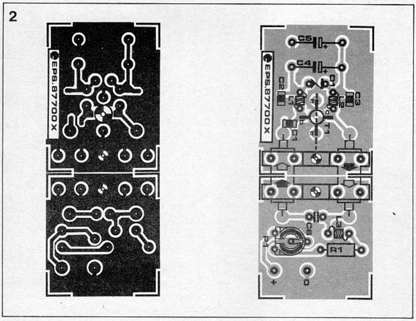

Fig. 2. The printed circuit board for the amplifier and its downlead power supply.

Parts list

Resistors (±5%):
R_1 = 270R
P_1 = 2K5 H

Capacitors:
C_1;C_2;C_3 = 1n0; SMD
C_4 = 2μ2; 16 V
C_5 = 47μ;16 V
C_6 = 1n0; ceramic

Semiconductors:
D_1 = zenerdiode 4V7; 400 mW
T_1 = BFG65

Inductors:
L_1;L_2;L_3 = see text.

Miscellaneous:
PCB Type 87700X (not available through the Readers Services).
Mains adaptor, 12 VDC; 100 mA.

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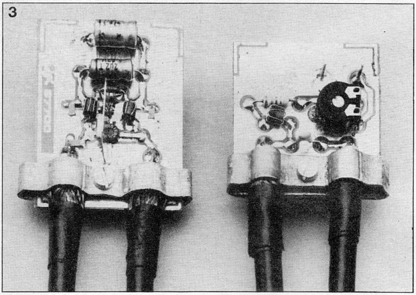

Fig. 3. The completed amplifier and supply boards connected to the coax cables.

between the collector and the base whilst passing current through D_1. The combination of electrolytic and SMD capacitors (C_5-C_2 and C_4-C_3) ensures optimum decoupling for the entire frequency range of the amplifier.

The aerial booster plus supply section is constructed on the PC board shown in Fig. 2. All parts are fitted at the copper side. The PCB is cut to separate the amplifier and the supply section. Drill a 5 mm hole to receive T_1, whose leads are cut to size, and soldered flat onto the relevant copper areas. Ascertain the pinning before fitting the BFG65! SMD capacitors C_1, C_2 and C_3 are carefully glued into position before soldering. Inductors L_1 and L_2 are wound as 6 turns of ∅0.2 mm (36SWG) enamelled copper wire through miniature (3 mm) ferrite beads. The enamel coating is carefully scratched off the connecting wires, these are tinned, pushed through the respective holes, soldered at the copper side, and cut off at the other side of the board. The fitting of the zenerdiode and the 2 electrolytic capacitors should not present difficulties. Mount a small tin or brass screen across the transistor as shown on the component overlay. Figure 3 shows the completed aerial booster plus supply. Note that the coax cables are clamped onto the boards to ensure effective grounding, and the shortest possible connection of the centre core.

The amplifier is fitted in a waterproof ABS enclosure for fixing onto the aerial mast. Drill 2 or 3 small holes in the underside of the enclosure to prevent water gathering inside. The supply section is fitted in a small enclosure, located on the attic, or behind the TV set, together with the mains adaptor.

Turn the wiper of P_1 for maximum resistance. Measure the current drain of the completed amplifier by connecting an ammeter between the adaptor output and the +12 V input on the supply board. P_1 is carefully advanced until a weak station is sufficently amplified, without running into cross-modulation caused by stronger signals. Do not exceed 25 mA on penalty of damaging T_1. When the amplifier is used for distributing signals on the cable network as discussed above, it is recommended to replace T_1 by a Type BFG96, operated at a collector current of 75 mA (this may require adapting R_1).

Signal divider

The previously described amplifier has sufficient gain to enable dividing its output signal between a number of TV sets in the home. All the signal dividers to be described should obtain their input signal from C_6, i.e., they must **not** be fitted between the amplifier output and the supply.

The signal dividers are assumed to be terminated in 75 Ω. Figure 4 shows the most elementary set-up of a coax signal divider. Although the input signal is cor-

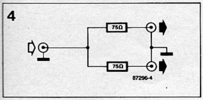

Fig. 4. This signal divider is too simple to give optimum results.

rectly terminated in 75 Ω, both TV sets at the outputs see a source impedance of

$$75 + (75//75) = 112.5\ \Omega.$$

A better circuit is shown in Fig. 5a. In this, there are three 25 Ω resistors and 3 termination resistors for the input and the 2 outputs. Each signal path has a 25 Ω resistor and a parallel combination with an equivalent resistance of

$$(25 + 75)/2 = 50\ \Omega$$

so that the characteristic impedance is 50 + 25 = 75 Ω. In the circuit of Fig. 5b, the signal amplitude on each of the 3 outputs is one third of that at the input. For an n-way divider, the value of R is calculated from

$$R = \frac{n-1}{n+1} \times 75[\Omega].$$

The resistor values obtained from this equation can be approximated with the nearest E12 or E96 value; for the 3-way and 4-way dividers of Figs. 5b and 5c, the respective values of 39 Ω and 47 Ω can be used with impunity.

It is possible to further subdivide the signal with the aid of the circuit shown in Fig. 6. This forms an alternative to the circuit in Fig. 5c, and enables economizing on coax cable, since the distribution point need no be central to all 4 connections. It is important to note that all outputs on the dividers described here require termination in 75 Ω, either by a TV or radio set, or, if this is not connected, by a 75 Ω resistor. Finally, Fig. 7 shows a practical version of a 2-way divider fitted in a metal enclosure to prevent stray radiation. *B;D*

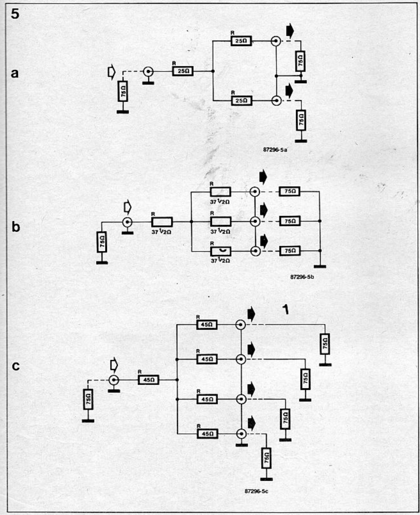

Fig. 5. Signal dividers that maintain the correct termination and source impedance in 75 Ω cable networks.

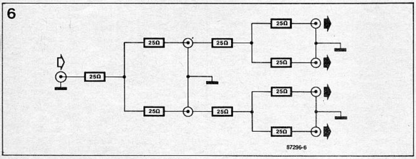

Fig. 6. An alternative 4-way signal divider.

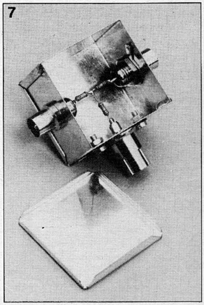

Fig. 7. Suggested construction of a 2-way signal divider in a metal enclosure.

Supply Decoupling

A circuit is only as good as its power supply. Even the best designed circuits can be upset by supply ripple, poor regulation, mains transients and power supply instability. IC voltage regulators have taken much of the donkey work out of power supply design for many applications, but the problems do not always end there.

Power supply circuits are usually designed almost as an afterthought. The circuit requiring power has probably been developed on the bench using the ubiquitous lab power supply. In general, a power supply for an electronic circuit should approximate an ideal voltage generator as well as possible. This means that the output voltage should remain constant over the normal output current operating range; in other words, the supply should have zero output impedance.

The supply voltage should not only remain constant under static conditions, but should also still remain constant when dynamic changes of current are occurring. As mentioned in the introduction, IC voltage regulators make it easy to achieve these objectives *at the output terminals of the supply,* but at points in the circuit remote from the supply the situation may be very different.

Depending on the type of circuit, the inductance of supply wiring and p.c. board tracks, though small, may have a dramatic effect. The worst offenders in this respect are probably TTL logic circuits. When the output state of a TTL gate changes this results in a change in the current drawn by the circuit of around 2 mA. A static current difference of 2 mA would probably result in a supply voltage variation of a few microvolts. The dynamic situation can be very different, however.

The fall (or rise) time of a TTL gate from logic 1 to logic 0 level is of the order of 10 nanoseconds. The rate of change of current $\frac{dI}{dt}$ is therefore 2 mA in 10ns or 200,000 amps/sec. The voltage V across an inductor L equals $L\frac{dI}{dt}$, so a wiring inductance of the order of 1 μH between the supply and the point where the current change occurred would result in a voltage drop of 200 mV.

This is, of course, a gross oversimplification, but it does demonstrate the sort of voltage transients that can occur on supply lines in TTL circuits. When such transients are of sufficient magnitude they can cause gates to change state and can cause spurious triggering of flip-flops, counters and monostables.

The problem can be attacked in several ways. The simplest approach is to provide local decoupling of the supply at various points in the circuit by means of small capacitors, typically 10 to 100n. These should preferably be ceramic types which have low self- inductance (figure 1a). Nine times out of ten this will effect a cure, but in some cases the cure can be worse than the disease, for it is possible that the capacitor will form a resonant circuit with the inductance of the supply lines. When this is excited by the switching transients of the TTL the problem can be magnified rather

than reduced.
The solution here is to damp the resonant circuit by including a resistor in series with each capacitor. 1 Ω carbon composition resistors should be used for this purpose (film types often have a high self-inductance). This is shown in figure 1b. An alternative to this is to use electrolytic capacitors of say 10 μ/6.3 V. Modern electrolytics have fairly low self-inductance, but the internal resistance is often sufficiently high to provided adequate damping.
Figure 2a shows the use of RC combinations to decouple several IC's fed from the same supply rail. Rather than using a single supply rail running from one IC to another a better solution, whenever possible, is to run separate supply rails from the power supply to each IC or group of two or three IC's. In this way interaction between the various IC's is reduced, since the self-inductance of each supply line actually helps to isolate the IC's from one another (figure 2b).
Another useful tactic is to make the supply lines fairly thin, as this increases their resistance and thus reduces the Q of the self-inductance. While on the subject of separate supply lines it is worth considering 'on-card stabilising'. In complex TTL systems, where there are several p.c. boards, a separate IC voltage regulator is often used on each board. This has several advantages:

1. Interaction between boards is virtually eliminated.
2. Heat dissipation is spread over several IC regulators rather than being concentrated in one central power supply, so cooling problems are reduced.
3. Each board can be fed from a remotely located unregulated supply without worrying about voltage drops along the supply lines (provided the voltage reaching the boards is sufficient for the regulators to operate).

Diode decoupling

Of course, not every circuit will be used with a stabilised supply, there are cases where it is simply not necessary or is uneconomic. In such cases the simple transformer, bridge rectifier and smoothing capacitor is generally used (figure 3). Off load this gives a reasonably constant d.c. voltage, but as the load current increases the supply will exhibit an increasing ripple voltage (see figure 5).
Some times a circuit requiring a ripple-free supply at a relatively low current, must be operated from the same unstabilised supply as a circuit requiring a higher current. A typical example of this is an audio amplifier where the preamp is fed from the same supply as the power amplifier. Generally, the power amplifier can tolerate higher ripple voltages than the preamp. Clearly some way must be found of isolating the preamp from the ripple voltage caused by the power amplifier.
This can be achieved by RC filtering, as in figure 3. The high current supply is taken from point 1, and a filtered, low current supply is taken from point 2. Clearly, the larger the values of R1 and C2, the more ripple-free will be the supply. However, R1 cannot be too large, otherwise increases in the load current I_2 may cause the voltage at point 2 to drop below an acceptable value. On the other hand R1 cannot be too small as increases in the load current I_1 may cause current to be 'robbed' from C2, should the voltage on C1 fall below that on C2.
These problems may be solved by using the circuit of figure 4. C2 will charge up to a voltage equal to the peak voltage on C1 minus the diode voltage drop. C2 will discharge at a rate determined by the time constant $C2/R_L$, regardless of what happens to the voltage on C1. Even if C1 were discharged by a momentary short circuit the voltage on C2 would be unaffected. The ripple level on C2 remains constant (for constant I_2), whatever the ripple on C1, as shown in figure 6.

RF Decoupling

It is essential in RF circuits that none of the RF signal appears on the supply lines. Not only does the possibility of unwanted radiation from the supply lines exist, there is also the chance of RF bring coupled back into other parts of the circuit. This can lead to instability in the case of positive feedback, or loss of gain in the case of negative feedback.
Wherever possible, RF circuits should be split up into units handling a single frequency or band of frequencies. Thus, for example, a double conversion receiver might be split up into front-end,

Figure 1a. The connecting wires between the stabilised supply (on the right) have a certain self-inductance. Rapid changes in load current can cause voltage drops across these inductances. A decoupling capacitor may help suppress this.
b. Under certain conditions the decoupling capacitor and lead inductances may form a resonant circuit, aggravating the problem. This can be damped by a low-value carbon composition resistor in series with the capacitor.

Figure 2a. In a large circuit or system, decoupling should be employed every one or two IC packages. However, stringing the supply along from one IC to the next is not the best way to eliminate coupling along the supply lines.
b. Here each IC or small group of IC's has its own supply lines. The self-inductance of the supply lines now actually inhibits coupling back from one IC to another.

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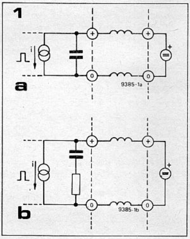

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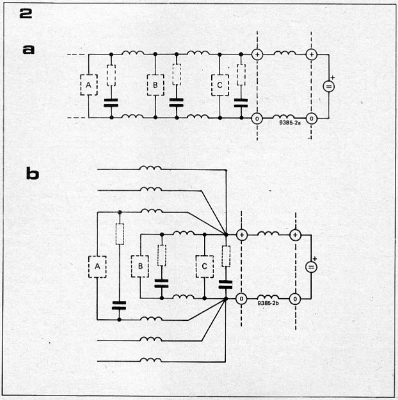

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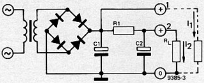

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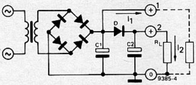

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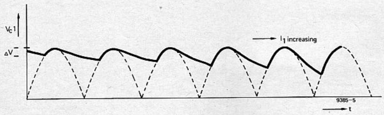

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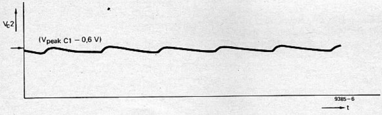


Figure 3. Where a ripple free supply is taken from a non-ripple free supply it may be smoothed by an RC filter.

Figure 4. Substitution of a diode for R1 gives a great improvement. Once C2 has charged it is completely isolated from C1 and the ripple depends solely on the current drawn by R_L.

Figure 5. Ripple voltage on C1 for increasing load current I_1.

Figure 6. The ripple voltage on C2 remains constant (for constant I_2) whatever the ripple voltage on C1.

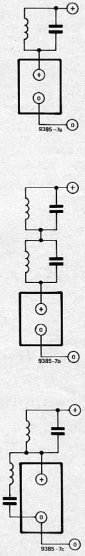
Figure 7. Three methods of supply decoupling in RF circuits. a. Narrowband filter. b. Wide stopband filter. c. Combination of parallel and series resonant circuits for VHF use.

7

a

b

c



first i.f. amplifier, mixer, BFO, second i.f. amplifier, demodulator and a.f. stages. Each of the stages would have its supply connection via a parallel resonant circuit tuned to the centre frequency handled by that stage (e.g. 10.7 MHz in the case of an f.m. i.f. amplifier). This will act as a wavetrap to prevent RF getting back onto the supply lines (figure 7a).

Where the circuit handles a wide range of frequencies it may be necessary to use a filter with a wider stopband by connecting two or more resonant circuits (of different frequencies) in series, as in figure 7b.

At very high frequencies the use of a series resonant circuit to shunt unwanted RF. signals down to ground is also recommended. The combination of parallel resonant and series resonant circuits is shown in figure 7c. For circuits working in the hundreds of megahertz the required inductance for the series circuit can be obtained simply by trimming the capacitor leads to an appropriate length. ■

MINI – SYNTHESIZER

The sound of electronic organ and synthesizer has become quite common everywhere. However, if you want to buy an instrument from the market it would be quite costly.

What we have presented here is a simple low cost circuit for a Mini-Synthesizer. It will also help you in learning how the electronic synthesizer functions. The description is not only of the electronics involved, but also includes references to 'tones' and 'octaves'. What voltages and frequencies mean to the electronics expert, tones and octaves mean to the musician.

To fully understand the mini synthesizer one must have at least a working knowledge of both – the voltages and frequencies, as well as the tones and octaves.

Block Diagram

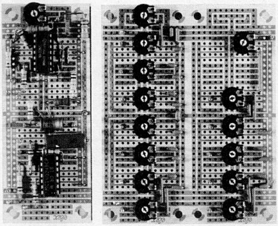
Figure 1 shows the simplified block diagram of our synthesizer. On the left side is the 'Tone Register' or the part which decides the tone that will be produced. Then comes the heart of the synthesizer – the VCO, or the Voltage Controlled Oscillator. The frequency of the VCO is dependant on the DC voltage present at its input. In case of a professional electronic organ, there are twelve individual oscillators, which form the basic tone generators. Other octaves are desired from these main oscillators. In case of a synthesizer, there is one VCO (or sometimes more) which generates the frequencies, depending on the DC voltage at the input.

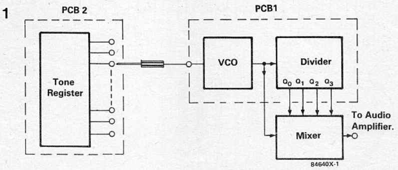
In case of the synthesizer circuit given here, we have thirteen different voltage inputs and one VCO. These thirteen voltage inputs are available in the Tone Register, which is nothing but a bank of trimpots connected across a reference voltage. The sliding contacts of the trimpots are set at different positions so that they give different voltages. These voltages are used as the control voltages for the VCO. The connection between the tone register and the VCO is through a flexible wire, with a probe tip soldered at one end. The other end being permanently soldered to the VCO input. Thus by tonching the various outputs from the tone register with the probe tip, different frequencies can be generated by the VCO.

The output of the VCO goes to a mixer. This delivers the highest frequency. Secondly, this output also goes to a frequency divider which divides the VCO frequency by 2, 4, 8 and 16 and gives four different output frequencies. These four outputs of the frequency divider are also fed to the mixer. All these five inputs of the mixer pass through switches, and can be connected or cut off

Figure 1:

Block diagram of the mini-synthesizer, giving a simplified overview of the circuit.





from the mixer as desired. The divider thus forms the sub-octave generator. These sub-octaves can be mixed with the main frequency by closing the switches. By opening the switch in the main frequency input and only closing the switches in the sub-octave inputs, it is possible only to feed the sub-octaves and not the main frequency. The mixer also consists of potentiometers to decide how much percentage of which frequency passes through to the amplifier.

The Circuit

The complete circuit (except the amplifier, of course.) of the mini-synthesizer is given in figure 2. The circuit is exactly similar to the block diagram we studied in figure 1. You can easily recognise the tone register, the frequency divider and the mixer. The VCO consists of A1 and A2, whereas A3 and A4 just serve as buffers to avoid overloading the circuit.

The tone register is formed by the trimpots P1 to P14. The VCO consists of A1, A2, R1, R2, R3, P15, C1 and D1. The frequency divider is formed by IC2. The mixer consists of potentiometers P16 to P20, resistors R6 to R11 and switches S2 to S6.

A3 forms the buffer which generates the voltage reference for the tone register and virtual ground for all other Op amps. R4 and R5 are part of a voltage divider which give a voltage of 4.5 V at the non inverting input of A3. The inverting input of A3 is shorted to its output, so that A3 behaves as a voltage follower, and the output is stabilised at 4.5 V. This output is used as the reference for the tone generator. It also serves as the virtual ground for the other Op amps, thus eliminating the need for a dual power supply. Effectively it generates a supply with + 4.5V, − 4.5 V and the virtual ground. The current consumption for the circuit is about a few mA, and the 9V battery can last for a long time.

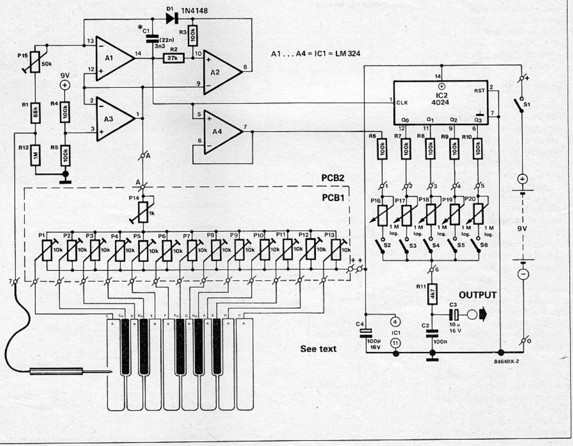
The trimpots P1 to P13 are connected parallely across the 4.5 V reference supply through a common trimpot P14. The total resistance of the parallel bank of resistors comes to about 770Ω and P14 is also adjusted to about the same value. The voltages at the sliding contacts of P1 to P13 lie between 2.25 and 4.5 V with reference to the virtual ground. These voltages are brought out an a piano type key pattern made of aluminium or copper foil.

The input to the VCO is taken through a flexible wire with a

Figure 2:

The detailed circuit of the synthesizer.
There are four main sections – The Tone Register, VCO, Frequency divider and the Mixer.

2



probe tip soldered at one end. The input circuit consists of trimpot P15 and resistors R1 and R12.

Capacitor C1 is charged through the input circuit, at a current maintained constant by the Op amp A1. The value of the charging current is decided by the applied voltage on the probe tip. The input offset of the Op amp is very low, and with the capacitor charging at a constant current, the output voltage of A1 becomes negative with respect to the virtual ground. As a result of this the output voltage of A2 jumps from + 4.5V to − 4.5 V. Now the diode D1 becomes forward biased and allows the capacitor C1 to discharge. The Op amp Az keeps the discharge current at a constant value. When C1 is discharged, output of A1 again becomes positive and forces the output of A2 also to become positive. Output of A2 now jumps to + 4.5 V again. The charging discharging cycle thus repeats, and what we get at the output of A1 is a triangular wave with frequency proportional to the input voltage.

Figure 3 shows the VCO section of the circuit again, along with the voltage wavefırmes present at different points in the VCO.

The output of the VCO at pin 14 is fed to the mixer through the buffer A4.

Inside the mixer circuit, it also passes through R6, to the potentiometer P16. Pin 14 also feeds the frequency divider IC 4024, which gives four outputs Q_0, Q_1, Q_2 and Q_3. These are ½, ¼, ⅛ and $^1/_{16}$ of the input frequency. These signals pass over resistors R7, R8, R9 and R10 to the potentiometers P17, P18, P19, and P20 of the mixer circuit. The mixed signal appears at R11 and goes out to the amplifier over capacitor C3.

Switches S2 to S6 are the octave selector switches, which decide the signals to be mixed to produce the output of the synthesizer. The settings of P16 fo P20 decide the percentage in which these octaves are mixed in the output signal. R11, C2 and C3 combination serves as a low pass filter and improves the quality of the sound generated by the synthesizer. The output can be connected to any suitable audio amplifier.

Construction

Figures 4 and 5 show the component layout of the circuit in two parts. Figure 4 shows the VCO and the frequency divider, whereas figure 5 shows the tone register.

Connection of the VCO input must be done through a shielded wire, and the shield should be connected to ground. The components of the mixer circuit should be wired directly in the sythesizer enclosure. The keyboard should be constructed on the top of the enclosure, using aluminium foil or copper foil. If you have a facility for etching PCBs, it can be etched on a PCB and mounted on top of the enclosure. Your craftsmanship will be the limit on how good a keyboard you can construct. The minimum requirement being that it should be able to make an electrical contact! Figure 6 shows the keyboard pattern. You can use a combination of aluminium and copper foil to give an appearance of white and black keys. Don't paint the black keys with black paint.

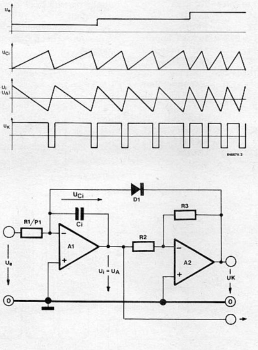
Figute 7 shows one of the methods to connect the keyboard to the tone register.

Alignment

After the electronics is finished, the musical alignment must be done. The so called tuning of the synthesizer. For this you will need a properly tuned reference instrument, a piano, a flute or a guitar. The tuning procedure is as follows:

1. Close S2, let S3 to S6 remain open.
2. Bring P13 approximately to the upper limit.
3. Adjust P1 almost near the lower limit.
4. Close S1, and switch on the audio amplifier.
5. Align P14 in such a way that between the highest and lowest tone lies approximately 1 octave. Adjust P13 again if required.

3



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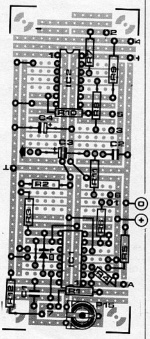


Figure 3:

The VCO Section reproduced for better understanding, with important voltage waveforms at various points inside the VCO.

Figure 4:

Component layout of the VCO and the frequency divider, on SELEX PCB – size 1.

6. Change the tone position with P15 in such a way that the lowest tone corresponds to the "C" of the reference instrument. Change C1 if essential.
7. Adjust tones C to H with P2 to P12 to match with the tones of the reference instrument.
8. After the rough alignment, check everything again, because the trimpots are all in parallel and have mutual effect on the tuning.

This completes the tuning procedure, and now you can have the real fun.

Close S3 to S6 in any desired combinations, set the potentiometers P16 to P20 as desired, and connect your synthesizer to a powerful Hi-Fi system.

If you are not using the frequency divider, and using the VCO output directly, C1 must be increased to a higher value, so that the highest frequency is not too high. Suggested value is 22 nF instead of 3.3 nF.

Component list

R1	= 68 KΩ
R2	= 27 KΩ
R3 to R10	= 100 KΩ
R11	= 4.7 KΩ
R12	= 1 MΩ
P1 to P13	= 10 KΩ Trimpots
P14	= 1 KΩ Trimpot
P15	= 50 KΩ Trimpot
P16 to P20	= 1 MΩ log potentiometers.
C1	= 3.3 nF (or 22 nF)
C2	= 100 nF
C3	= 10 uF/16V
C4	= 100 uF/16V
D1	= 1N 4148
IC1	= LM 324
IC2	= 4024
S1 to S6	= SPST switches.

Other Parts:

SELEX PCBs Size 1 and 2
9 V battery
Probe tip with flexible wire (shielded)
Material for Keyboard
5 pin Din Socket & Connector for output.

Figure 5:

Component layout of the Tone register on SELEX PCB – size 2.

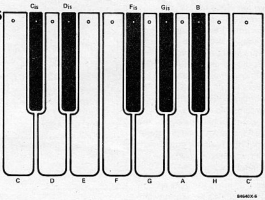
Figure 6:

The "Keyboard" pattern for those who are also skilled craftsmen.

Figure 7:

Suggested method of connecting the keyboard to the tone register.

6



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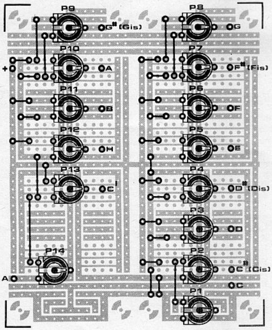

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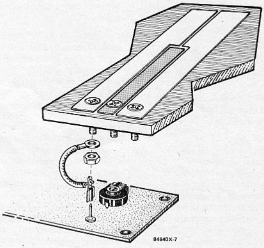

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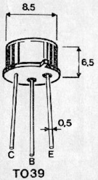
Transistors
Type 2N2219 & 2N2219A



The collector of these transistors is connected to the case.
These transistors can be used to form a complementary pair with Types 2N2905 and 2N2905A respectively.

DC current gain, h_{FE}, when:

$I_C = 1$ mA; $U_{CE} = 10$ V	>50
$I_C = 10$ mA; $U_{CE} = 10$ V	>75
$I_C = 150$ mA; $U_{CE} = 1$ V	>50 (a)
$I_C = 150$ mA; $U_{CE} = 10$ V	100-300 (a)
$I_C = 500$ mA; $U_{CE} = 10$ V	>30 (a)(b)
$I_C = 500$ mA; $U_{CE} = 10$ V	>40 (a)(c)

(a) with I_C as a pulse
(b) 2N2219 only
(c) 2N2219A only

The 2N2219 and 2N2219A may be used as substitutes for the 2N2218 and 2N2218A respectively, but note that the DC current gain, h_{FE}, is greater in the former types.

Elektor Electronics
Infosheet 511

Semiconductor manufacturers and their UK distributors

Manufacturer: **TELEDYNE PHILBRICK MICRO-CIRCUITS**
Allied Drive — Route 128
DEDHAM
Mass. 02026 - U S A

Distributors:	**Telephone:**
Active Electronics	(0494) 441129
Aviquipo of Britain	(0628) 34555
Barrie Electronics	(01) 555 0228
Macro-Marketing	(06286) 4422
Merlin Electronics	(0622) 678888
Micromark Electronics	(0628) 72631
Norsem	(0734) 884588
Polar Electronics	(0525) 377093
Semicomps	(0535) 65191
Semiconductor Supplies	(01) 643 1126

Manufacturer: **T R W**

Distributors:	**Telephone:**
M C P Electronics	(01) 902 6941
M D L Components	(0202) 781331
Semiconductor Supplies	(01) 643 1126

Manufacturer: **TOSHIBA UK LIMITED**
Toshiba House
Great South West Road
FELTHAM — Middlesex

Distributors:	**Telephone:**
Active Electronics	(0494) 441129
Aviquipo of Britain	(0628) 34555
Consort Electronics	(0252) 871717
Impulse Electronics	(0883) 46433
JATA (Electronics)	(0724) 42636
Polar Electronics	(0525) 377093
Semi Components	(0932) 241866
Semiconductor Supplies	(01) 643 1126
Steatite	(021) 454 2655

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Semiconductor manufacturers and their UK distributors

Manufacturer: **SOLID STATE SCIENTIFIC**
175 King Street
LONDON W6 9NF

Distributors:	**Telephone:**
Active Electronics	(0494) 441129
Aviquipo of Britain	(0628) 34555
Barrie Electronics	(01) 555 0228
Merlin Electronics	(0622) 678888
Rastra Electronics	(01) 748 3143
Semiconductor Specialists	(08954) 45522
Semiconductor Supplies	(01) 643 1126
Solid State Scientific	(01) 748 3143

Manufacturer: **SPRAGUE ELECTRIC UK LIMITED**
Salbrook Road
SALFORDS
Surrey RH1 5DZ

Distributors:	**Telephone:**
Ace Mailtronix	(0924) 441129
Active Electronics	(0494) 441129
Campbell Collins	(0438) 69466
Dialogue Distribution	(0276) 682001
H B Electronics	(0204) 387731
Hunter	(0628) 75911
JATA (Electronics)	(0724) 42636
Merlin Electronics	(0622) 678888
Polar Electronics	(0525) 377093
Semiconductor Supplies	(01) 643 1126
Swift Sasco	(0293) 28700

Elektor Electronics
Datasheet 38

Transistors
Type 2N2219 & 2N2219A

Type

These NPN transistors are intended for fast switching applications.
The 2N2219 is also suitable for use in DC, VHF, and UHF amplifiers.

Characteristics

Collector cut-off current, I_{CBO} [U_{CB} = 50 V (2N2219); 60 V (2N2219A)]		≤10 nA
Emitter cut-off current, I_{EBO} [U_{EB} = 3 V]		≤10 nA
Collector to emitter voltage, $U_{CE(sat)}$	2N2219	≤0.4 V
[I_B = 15 mA; I_C = 150 mA]	2N2219A	≤0.3 V
Current gain-bandwidth product, f_T	2N2219	≥250 MHz
[I_C = 20 mA; U_{CE} = 20 V; f = 100 MHz]	2N2219A	≥300 MHz
DC current gain, h_{FE} (see also reverse side) [I_C = 0.1 mA; U_{CE} = 10 V]		>35
Noise figure, F_{dB} [2N2219A: I_C = 0.1 mA; U_{CE} = 10 V; R_{gen} = 1 kΩ; f = 1 kHz; B = 1 Hz]		<4 dB

Limits

	2N2219	2N2219A	
U_{CBO}	60	75	V
U_{CEO}	30	40	V
U_{EBO}	5	6	V
I_C	800	800	mA
P_D	800*	800*	mW
	3**	3**	W
T_J	175	175	°C
$R_{\theta(j-a)}$	190	190	K/W
$R_{\theta(j-c)}$	50	50	K/W

* up to T_a = 25 °C
** up to T_c = 25 °C

Data are valid only for conditions stated.

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